New York State Education Department

New York State Museum

63d ANNUAL REPORT

1909

In 4 volumes

VOLUME 4

APPENDIX 6

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ALBANY
UNIVERSITY OF THE STATE OF NEW YORK
1911

STATE OF NEW YORK

EDUCATION DEPARTMENT

Regents of the University

With years when terms expire

STATE OF NEW YORK

No. 45

IN ASSEMBLY

FEBRUARY 21, 1910

63d ANNUAL REPORT

OF THE

NEW YORK STATE MUSEUM

VOLUME 4

To the Legislature of the State of New York

We have the honor to submit herewith, pursuant to law, as the 63d Annual Report of the New York State Museum, the report of the Director, including the reports of the State Geologist and State Paleontologist, and the reports of the State Entomologist and the State Botanist, with appendixes.

ST CLAIR MCKELWAY
Vice Chancellor of the University
ANDREW S. DRAPER
Commissioner of Education

Appendix 6

Museum Memoir 13

Calcites of New York

New York State Education Department

New York State Museum

JOHN M. CLARKE, Director

Memoir 13

CALCITES OF NEW YORK

BY

HERBERT P. WHITLOCK

ALBANY

UNIVERSITY OF THE STATE OF NEW YORK

1910

STATE OF NEW YORK

EDUCATION DEPARTMENT

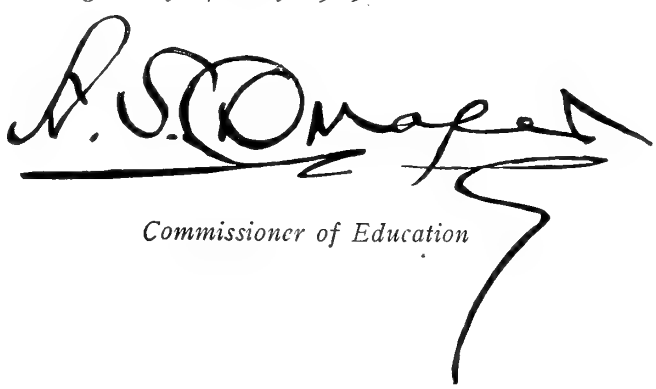
New York State Education Department
Science Division, May 10, 1909

Hon. Andrew S. Draper LL.D.
Commissioner of Education

My dear sir: The accompanying manuscript is a treatise on the *Calcites of New York* which I have the honor to recommend for publication as a memoir of the State Museum. This work has been skilfully executed by Herbert P. Whitlock, Mineralogist, and its excellence entitles it to publication.

Very respectfully
John M. Clarke
Director

State of New York
Education Department
commissioner's room
Approved for publication this 13th day of May 1909



Commissioner of Education

New York State Education Department

New York State Museum

John M. Clarke, Director

Memoir 13

CALCITES OF NEW YORK

BY

HERBERT P. WHITLOCK

INTRODUCTION

Among the great number of crystallized mineral species there is no single mineral which presents such remarkable variety of crystallographic forms and combinations of forms, as calcite. When in addition to the foregoing fact we consider the no less important one that no mineral is of such universal occurrence or is produced under such varying conditions, it would seem that here, if anywhere, lay the key to the great problem of the influence of genetic conditions upon the crystal habit of minerals. In the present monograph the writer has aimed to bring to the aid of the study of this problem, crystallographic notes on a number of calcite occurrences within the limits of New York State. Such a work must of necessity retain the incompleteness devolving upon the limitations of present knowledge as to undeveloped localities. It is, therefore, hoped that with progress in the exploration and study of new localities the present volume will be supplemented by further work on this very interesting mineral.

The writer has drawn freely upon his previously published notes both for descriptive matter in the text and for illustrations of the crystallographic combinations shown in the plates. Much of the previously described material has, however, been restudied and in most instances the figures redrawn.

The writer is under obligations to the following gentlemen for valuable type material and for many courtesies extended to him in the furtherance of his work: Messrs John M. Clarke, State Geologist; D. H. Newland, Assistant State Geologist; C. A. Hartnagel; H. H. Hindshaw; Thomas Cameron; R. S. Hodge; P. E. Clark; F. W. Kelley; G. H. Chadwick; H. C. Wardell; C. Wait; H. C. Peck.

PREVIOUS WORK

During the last century comparatively little work was done on New York calcites, the interest of mineralogists being centered almost entirely upon one occurrence, that at Rossie, St Lawrence co. Cleaveland, writing in 1822, mentions seven New York localities for calcite, viz: Dutchess county, Catskill, Bethlehem, Diamond island and Rogers rock (Lake George), Ticonderoga, and Niagara Falls. His notes on these localities are limited to such crystallographic identification as could be made by the unaided eye and, with the exception of the Niagara Falls locality where he identified the cuboid of Haüy ($-\frac{3}{2}R$), may be passed without comment. In 1825 Robinson, in his *Catalogue of American Mineral Localities*, notes 25 localities for calcite in New York. His notes, however, contain little information as to the occurring crystal forms other than that previously given by Cleaveland.

C. U. Shepard, in the first volume of his treatise published in 1835, illustrates a calcite crystal from Leyden, Lewis co. This is the common prismatic habit terminated by $-\frac{1}{2}R$.

J. D. Dana, in the first edition of his *System of Mineralogy* (1837), illustrates a combination from Rossie showing the common forms R3 and R. He also mentions in the text the localities at Oxbow, St Lawrence co. and Lockport, Niagara co. The latter locality was previously mentioned in Robinson's list.

In 1842 Dr L. C. Beck published his *Mineralogy of New York* in which 14 pages are devoted to calcite localities and 45 figures in the text illustrate the simpler crystallographic combinations. The following forms are shown singly or in combination: ∞R, 16R(?), 4R, R, 0R, $-\frac{1}{2}R$, $-\frac{4}{5}R$(?), $-\frac{3}{2}R$, $-5R$, $\frac{1}{4}R3$ and R3. Of the 33 localities mentioned by Beck those at Tompkins Cove, Rockland co. and Rossie, St Lawrence co. are described at length and the crystals figured in detail. The calcite crystals from Rossie are illustrated in five figures showing combinations of the forms 0R, R and R3, twinned parallel to 0R, the twinned crystal being shown in

various positions. Figure 93 of Beck is identical with that previously mentioned in Dana's first edition.

In the fifth edition of Philip's *Elementary Treatise on Mineralogy*, edited by Francis Alger and published in 1844, a twinned crystal from Rossie is illustrated which differs somewhat from those of Beck, but shows only the forms 0R and R.

In a review of Beck's *Mineralogy of New York* by J. D. Dana, published in the *American Journal of Science* 1844, the latter writer adds two figures illustrating the calcite from Rossie, the first of which is of special interest as showing several modifying planes. It is unfortunately impossible positively to identify these forms as no crystallographic description is given in the text and the lettering of the figure could not be traced.

Leonhard, in the *Jahrbuch für Mineralogie* 1849, notes eight New York localities for calcite all of which were described by Beck.

In a report embodying additional notes on the mineralogy of New York, published in the *Third Annual Report of the State Cabinet of Natural History* 1850, Beck republishes the illustration from Alger noted above and adds a cut of a crystal of prismatic habit from Tompkins Cove twinned parallel to $-\frac{1}{2}$R. Two woodcuts which accompany this paper show calcite from Anthony's Nose, Westchester co. of prismatic habit, tabular parallel to the basal plane.

In the *Fourth Annual Report of the State Cabinet of Natural History* 1851, Franklin B. Hough figures several simple combinations of the forms 0R, R and R3 from Wegatchie, St Lawrence co. as well as a complex twin crystal from Gouverneur in the same county. The latter shows no lettering by which the forms can be identified but is apparently a combination similar to those previously noted from Rossie.

Zippe, in a monograph published in 1852, notes in figure 10, plate I a crystal of calcite from Rossie in K.K. Hof-Mineral-Cabinet an inch in size. On this crystal he observed the forms R, 4R and 4R2 and also notes on small drusy crystals from the same specimen the forms -2R and $\frac{2}{5}$R2.

In 1860 Hessenberg published in the third instalment of his Mineralogical Notes, a short paper on "Some Rossie Calcite Crystals." He notes two new positive scalenohedrons $2R\frac{1}{4}\frac{1}{}$ $(15.7.\overline{22}.4)$ and $\frac{3}{3}\frac{2}{5}R\frac{1}{4}\frac{1}{}$ $(60.38.\overline{88}.35)$ both of which are advanced by him with some misgivings as to their true indexes and the latter of which was measured on only two of the three edges and to the nearest even degree, showing considerable uncertainty in determination due probably to poor reflections.

In 1878 Irby[1] published a *Monograph on the Crystallization of Calcite* in which he classes the two scalenohedrons $2R\frac{1}{4}\frac{1}{}$ and $\frac{3}{3}\frac{2}{5}R\frac{1}{4}\frac{1}{}$ of Hessenberg in the list of doubtful forms.

In 1888 Nason published a bulletin on *Some New York Minerals and their Localities*, which includes a short paper on the calcite crystals collected by Professor Emmons from the Rossie lead mines. Mr Nason states in his introduction that he has not attempted a technical description and consequently we find in his work no references to the previous work of Zippe, Hessenberg and Dana, and his crystallographic description is confined to the recognition of the forms 0R, R and R3 and to the republication of Beck's figures.

J. F. Kemp, in his *Notes on the Minerals Occurring near Port Henry* (1890) mentions some calcite crystals showing the forms R, 4R, $\frac{3}{7}R\frac{9}{5}$ and $\frac{1}{1}\frac{3}{1}R\frac{9}{7}$, the two latter in oscillatory combination. His accompanying figure is republished in the sixth edition of Dana's *System of Mineralogy*.

Penfield and Ford in 1900 described the calcite crystals from Union Springs, Cayuga co. and noted several rare forms in addition to a rare twinning habit.

[1] Irby, J.R.McD. Inaug. Diss. Bonn. 1878.

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While the foregoing bibliography represents the literature of New York calcite, it is manifestly inadequate for the purposes of identification and

comparison of forms with those observed in connection with other occurrences. The following general bibliography embodies the more important of the earlier works on the crystallization of calcite with a more detailed compilation of the literature which has appeared since the publication of Goldschmidt's *Index der Krystallformen der Mineralien*. The list is by no means exhaustive and is limited to articles which bear directly on crystal habit or which contain discussions of new forms:

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MATHEMATICAL RELATIONS AND FORMULAS

General types of forms. The fundamental form of calcite and consequently the one which is used as a basis in all systems of symbol nomenclature is the primary rhombohedron, familiar as the cleavage form. Assuming the ideal development of this form shown in figure 1,[1] it will be seen to be bounded by six similar rhombic faces which intersect in six equal lateral edges forming a zigzag line around the crystal, and six equal terminal edges, three of which form the upper and three, in alternate position the lower terminal solid angle. By joining the middle points of the opposite lateral edges by three intersecting lines and the terminal angles by a fourth, we get the system of dotted lines shown in the figure. Considering figure 1 in vertical projection or "plan" [fig. 2] two facts are to be noted.

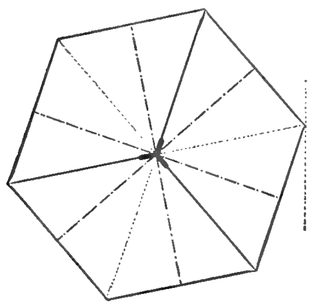

Fig. 2

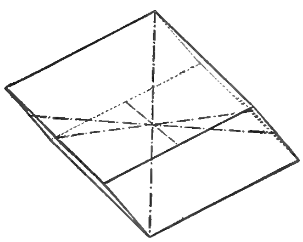

Fig. 1

1 The vertical dotted line is an axis of trigonal symmetry or threefold symmetry.

2 The three dotted lines joining the lateral edges are equal, equally inclined and lie in a plane perpendicular to the vertical dotted line. These four lines constitute the crystallographic axes of the hexagonal system. The ratio of the length of the vertical axis to each of the horizontal or basal axes, for calcite is represented by the proportion .8543:1, this ratio being determined by the unit form which is the cleavage rhombohedron.

Base. If now, a pair of planes be assumed normal to the vertical axis, they will truncate the terminal solid angles as shown in figure 3, producing

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[1] In this as in all other pictorial projections unless otherwise stated the crystal is shown in clinographic parallel perspective, that is the crystal is assumed to be revolved 18° 26′ to the right, and the upper termination is inclined 9° 28′ to the front of the plane of vision.

the faces of the base or basal pinacoid. Since this form is normal to an axis of trigonal symmetry the face resulting from its combination will in every instance show trigonal symmetry.

Prisms. A series of six planes each parallel to one basal axis and to the vertical axis will intersect the fundamental rhombohedron in the faces which truncate the six lateral solid angles figure 4. In this instance the resulting faces are isosceles triangles the vertexes of which are turned

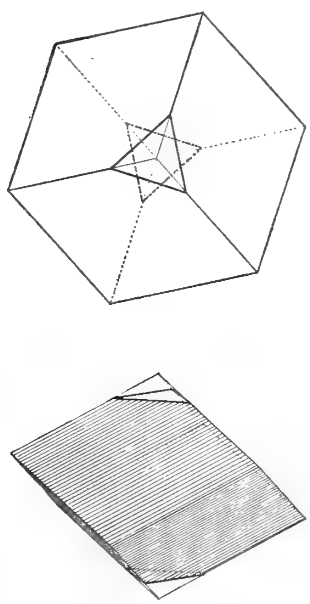


Fig. 3

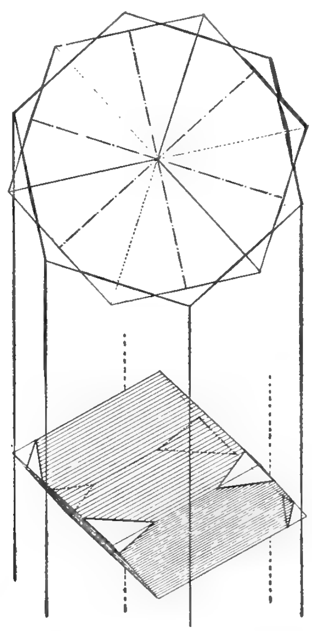


Fig. 4

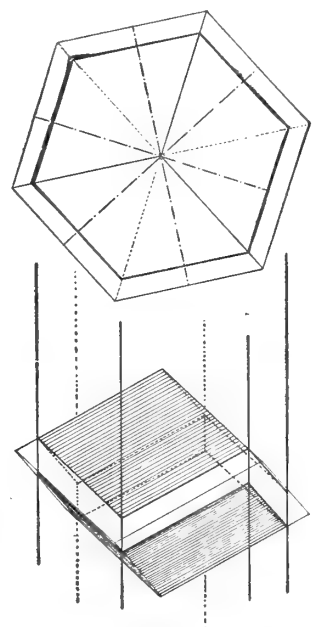


Fig. 5

alternately up and down. In every case where this prism enters into combination with other rhombohedral-hexagonal forms, the resulting faces show binary symmetry parallel to the vertical axis. This is the unit prism or prism of the first order.

A series of six planes each perpendicular to one basal axis and parallel to the vertical axis, will intersect the fundamental rhombohedron as shown in figure 5. These planes which are those of the prism of second order are parallel to the lateral rhombohedral edges and in combination with forms of rhombohedral symmetry (rhombohedrons and scalenohedrons) produce faces of unsymmetrical outline but which are symmetrical in adjacent

pairs. Thus in figure 5 every plane of the second order prism is symmetrically disposed to its corresponding adjacent face on the right and left.

A very limited number of dihexagonal prisms are recorded for calcite. These are 12-sided prisms the planes of which are parallel to the vertical axis and intersect all three of the basal axes at unequal distances. The alternate lateral edges are similar and the faces are symmetrical in adjacent pairs. The forms are of comparatively rare occurrence.

Pyramids. Assuming the basal section of the prism of the second order shown in figure 5, suppose a series of double pyramids to be constructed

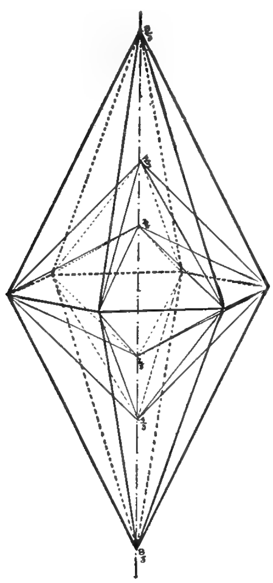


Fig. 6

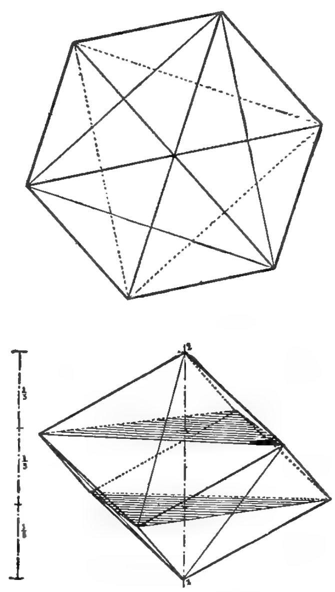


Fig. 7

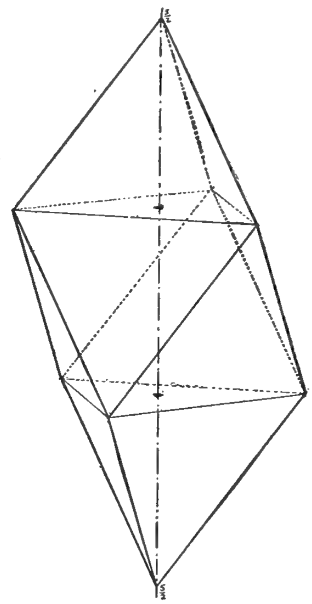


Fig. 8

having for common base the above mentioned basal section and with their vertexes lying on the vertical axis at definite proportions of its length. Such a series of pyramids is shown in figure 6 the proportions of the intercepts on the vertical axis being chosen to show some of the more frequent pyramids of the second order of calcite. The possible number of forms of this type is not limited save by the law of rational indexes. The symmetry of pyramids of the second order is that of the prism of the second order. In combination with forms of rhombohedral symmetry the faces of pyramids

of second order are of unsymmetrical outline but like those of the prism of the second order they are symmetrical in adjacent pairs to vertical planes passing through the terminal edges [*see* pl. 10, fig. 1–5].

Rhombohedrons. Returning to the consideration of the fundamental rhombohedron assume the diagonals of rhombic faces to be drawn as shown in figure 7. It is plain from the vertical projection of figure 7 (upper half of figure) that the horizontal diagonals, in this case the long diagonals, of the rhombic faces form two equilateral triangles having their centers in the vertical axis. If two planes be passed perpendicular to the vertical axis and intersecting the rhombohedron in these two triangles, as shown in the figure, it is clear that the distance between the planes is equal to the distance of each from the nearest vertex; that is the planes through the horizontal diagonals divide the vertical axis into three equal parts. The triangles referred to may be designated as the triangles of the horizontal diagonals. Assume now, a vertical line the length of which is some proportion of the vertical axis of calcite, as $\frac{5}{2}$. If this line be divided into thirds by horizontal planes upon which the triangles of the horizontal diagonals be constructed and the vertexes joined as shown in figure 8, the resulting solid will be a rhombohedron having the same vertical projection as figure 7 and the vertical length of which is $\frac{5}{2}$ times that of the fundamental rhombohedron. Similarly any number of rhombohedrons may be developed having various vertical intercepts the ratios of which are limited by the law of rational indexes. The rhombohedrons of this series are designated as positive. Up to the present there have been recorded 29 positive rhombohedrons for calcite the flattest of which has a vertical length of $\frac{1}{4}$ the vertical ratio and the steepest of which has a vertical length of 28 times the same ratio. The limits of this series are the basal pinacoid having a vertical intercept of 0 and the prism of the first order having a vertical intercept of ∞, the latter forms being respectively parallel to the basal axes and to the vertical axis [*see* fig. 3, 4].

Assuming the position of the triangles of the horizontal diagonals to be reversed, a series of rhombohedrons may be developed in the same

manner two of which are shown in figures 9 and 10, the vertical lengths of these being respectively in ratio of $\frac{1}{2}$ and 2 to the vertical axis of calcite. The rhombohedrons of this series stand in reversed relation to those of the positive series the faces of one corresponding to the terminal edges of the other; they are for this reason designated by the French crystallographers as *rhomboedre inverse* or in our system of nomenclature as negative rhombohedrons. As in the case of the series of positive rhombohedrons the limits of the series of negative rhombohedrons are the basal pinacoid and the prism of the first order. There have been recorded 54 negative rhombohedrons for calcite the flattest of which has a vertical length of $\frac{1}{5}$ and the steepest a vertical length of 36 times the vertical ratio. Positive and negative rhombohedrons are so related that the terminal edges of any positive rhombohedron are truncated by the faces of a negative rhombohedron of $\frac{1}{2}$ its vertical axial length or any negative rhombohedron is similarly modified in combination by a positive rhombohedron of $\frac{1}{2}$ its vertical axial length. This relation is shown in figure 11 which is a combination of the rhombohedrons shown in figures 7, 9 and 10.[1]

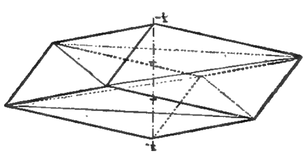


Fig. 9

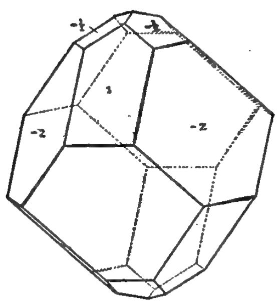


Fig. 11

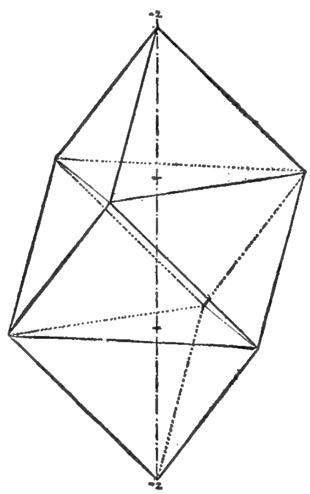


Fig. 10

Scalenohedrons. Taking as a basis the fundamental rhombohedron, assume its vertical axis to be extended to $\frac{3}{2}$, 2 and 3 times its vertical length and connect these points with the lateral angles of the rhombohedron by systems of lines as shown in figure 12. The three solids developed by this construction are each made up of 12 scalene triangles and have a common

[1] For examples of the symmetry of rhombohedrons in combination compare plate 6, figure 5.

system of lateral edges coinciding with those of the rhombohedron from which they are developed. These forms are designated as scalenohedrons; the foundational rhombohedron is known as the *rhombohedron of the middle edges.* Every rhombohedron may be theoretically assumed as a rhombohedron of the middle edges for a series of scalenohedrons the number of which is limited only by the law of rational indexes. So for every positive rhombohedron a series of positive scalenohedrons, and for every negative rhombohedron a corresponding series of negative scalenohedrons may be developed. Such a negative scalenohedron is shown in figure 13, developed from the negative rhombohedron of figure 9, the vertical length of the scalenohedron in this case being three times that of its rhombohedron of the middle edges. The 12 planes of every scalenohedron intersect in 12 terminal or polar edges which are relatively long and short and are alternately disposed around the vertical axis. The longer of these which measure the more obtuse polar dihedral angles correspond in position to the planes of the rhombohedron of the middle edges, and the shorter of which, which measure the more acute of the polar dihedral angles, correspond in position to the terminal edges of the rhombohedron of the middle edges. As the proportion of the vertical length of the scalenohedron to that of its foundational

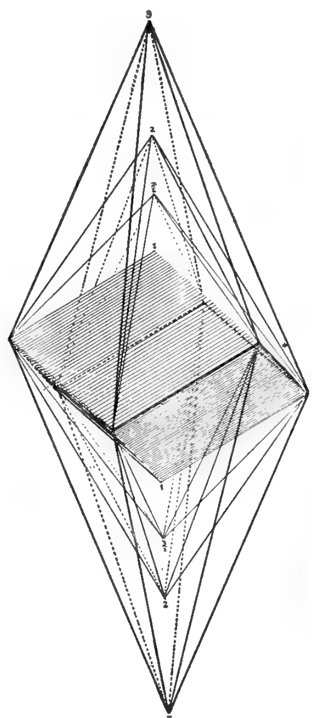


Fig. 12

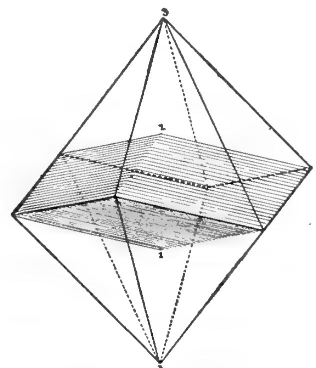


Fig. 13

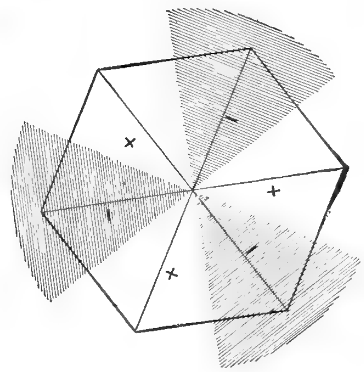


Fig. 14

rhombohedron increases the polar angles approach more nearly equality, equality being reached in the prism of the second order which is one of the limiting forms of every series of scalenohedrons. The other limit of the series is reached when the vertical length of the scalenohedron becomes that of its rhombohedron of the middle edges. In combination with other forms scalenohedrons develop crystal faces of unsymmetric outline. The faces like those of the pyramids of the second order are symmetrical in adjacent vertical pairs.[1] If the hexagon which represents the horizontal projection of any scalenohedron be divided by planes passed through the horizontal axes into sextants as in figure 14 the unshaded portions of the figure will represent the positive sextants and the shaded portions the negative sextants, above the zigzag line of the middle edges. The planes of positive scalenohedrons lie in pairs in the positive sextants and those of negative scalenohedrons in the negative sextants.

SYMBOLS

Naumann's system of symbols. The system of crystal nomenclature proposed by Naumann,[2] which is now in quite general use, has for its general feature the use of certain capital letters preceded and followed by numbers, which numbers indicate the ratio of axial intercepts. In the case of the hexagonal system the capital letters used are P and R. The capital letter R indicates the fundamental rhombohedron. Coefficients placed in front of R, as for example $\frac{5}{2}$R, 4R, 16R indicate respectively positive rhombohedrons whose length as compared with the vertical unit for calcite (.8543) are respectively $\frac{5}{2}$, 4 and 16 times. In the same way negative rhombohedrons designated as $-\frac{1}{2}$R, -2R, $-\frac{7}{2}$R, -5R have vertical intercepts respectively $\frac{1}{2}$, 2, $\frac{7}{2}$ and 5 times the unit vertical length. The basal pinacoid and the prism of the first order are limit forms of the rhombohedron series and are consequently designated respectively 0R and ∞R.

[1] For examples of the symmetry of scalenohedrons in combination compare plate 11, figure 4; plate 21, figure 3.

[2] Naumann, C. F. Lehrbuch der Krystallographic. Leipzig 1829.

The combination shown in figure 11 is made up of the forms $-\frac{1}{2}R$, R and $-2R$. The planes of the prism of the second order which are each perpendicular to one horizontal axis, intercept the two remaining horizontal axes at a distance from the center which is twice their unit lengths.[1] The Naumann symbol for the prism of the second order is $\infty P2$. A pyramid of the second order is designated by the symbol P2 preceded by a coefficient which indicates the vertical intercepts compared with the unit value of the vertical axis for calcite. Thus, the series of pyramids shown in figure 5 are represented by the symbols $\frac{2}{3}P2$, $\frac{4}{3}P2$ and $\frac{8}{3}P2$. Low values of the coefficient represent flat or obtuse pyramids of the second order and high values steep or acute pyramids. A scalenohedron is designated in the Naumann system of symbols by the symbol of the rhombohedron of its middle edges followed by a numeral which indicates the relative vertical length of the scalenohedron compared with that of its rhombohedron of the middle edges. The series of positive scalenohedrons shown in figure 12 are designated by the symbols $R\frac{3}{2}$, R2 and R3, R being the symbol of the rhombohedron of their middle edges. In the same way the negative scalenohedron shown in figure 13, which has for its rhombohedron of the middle edges the negative rhombohedron $-\frac{1}{2}R$ and which is three times the vertical length of that rhombohedron, is designated by the symbol $-\frac{1}{2}R3$.

The system of nomenclature employed by J. D. Dana in his earlier editions is very closely allied to that of Naumann. The prism ∞R of Naumann is indicated by i (infinity) in Dana's symbols, $\infty P2$ by $i-2$ etc. The pyramids $\frac{4}{3}P2$, 2P2, 4P2 of Naumann become $\frac{4}{3}-2$, $2-2$, $4-2$ etc., of Dana. In the symbol for rhombohedrons, Dana omits the capital letter R, substituting for it the numeral 1 in the case of the fundamental rhombohedron; thus R, 4R, $-\frac{1}{2}R$, $-2R$ etc., become in Dana's symbols 1, 4, $-\frac{1}{2}$, -2 etc. The same is applied to the scalenohedrons, the numerals indicating the vertical intercepts in Naumann being used as exponents by Dana; thus R3 becomes 1^3, $\frac{1}{4}R5$ becomes $\frac{1}{4}^5$, $-\frac{4}{5}R3$ becomes $-\frac{4}{5}^3$ etc.

[1] This property of the regular hexagon is subject of easy demonstration and may be found in every elementary textbook on geometry.

Bravais-Miller system of symbols. The system of symbols adopted by Bravais after the method of Miller has several points of superiority over other systems. It provided an expression for every face of a form and is particularly adapted to the determining of zonal relations by means of zone equations. This system or some modification of it is now in almost universal use.

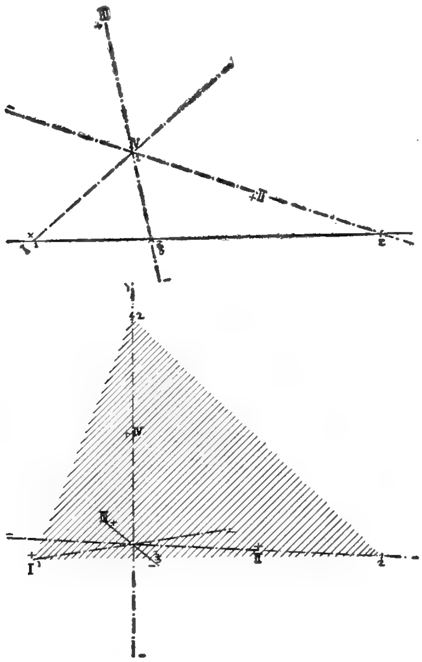


Fig. 15

The Bravais-Miller symbols are essentially a system of indexes, or relative intercepts of the axes, expressed in numbers. As applied to the hexagonal system these indexes are four in number, the first three relating to the horizontal axes and the fourth to the vertical axis. Assume the hexagonal axes numbered as shown in figure 15 and consider their extremities as positive and negative as indicated. Any plane having the position relative to these axes indicated by the shaded plane would intercept the axes in the proportion:

I	II	III	IV
1:	2:	$\frac{2}{3}$:	2

This proportion expresses the position of the chosen plane in space with respect to the hexagonal axes, but inasmuch as it is somewhat cumbersome, particularly when the intercepts are fractional ratios, Miller takes the reciprocals of the terms of the proportion and reduces them to whole numbers, placing a minus sign over the intercept on a minus axis thus:[1]

[1] In the first of the proportions, which is essentially the symbol as written by Weiss, the first term is 1. Calling the second term n, the third term will be represented by the expression $-\frac{n}{n+1}$ and the general expression for any plane referred to hexagonal axes may be written: $1 : n : -\frac{n}{n+1} : m$

$$1:2:-\frac{2}{3}:2=\frac{1}{1}:\frac{1}{2}:-\frac{3}{2}:\frac{1}{2}=2.1.\bar{3}.1$$

The latter expression is the Bravais-Miller symbol for this particular plane. The scalenohedron of which the above plane constitutes one of the faces is shown, with the Bravais-Miller symbols of the faces in figure 16. It will be noted that the numbers which constitute the indexes of the initial face $(21\bar{3}1)$ are repeated in different order (with respect to the first three) and with different sign for all the faces of the form. The form is designated by the indexes of that one of its planes which lies to the right in the front positive sextant, figure 14, the general expression for these indexes being $(h\ k\ \bar{i}\ l)$. In the above example $h = 2$, $k = 1$, $i = \bar{3}$ and $l = 1$. The general expression h k i l is modified in special cases. For positive rhombohedrons where the initial face is parallel to the axis II and intercepts I and —III equally, k in the general expression becomes 0 (i. e. $\frac{\infty}{1}$) and h is equal to i. The general symbol then for a positive rhombohedron is $(h\ o\ \bar{h}\ l)$ in which $\frac{h}{l}$ equals the coefficient of R in the corresponding Naumann symbol. Similarly the general symbol for a negative rhombohedron is (o h h l), Prismatic forms being parallel to the axis IV have for

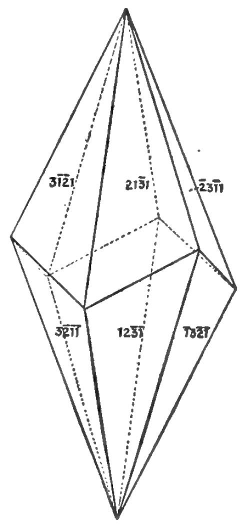


Fig. 16

the fourth index 0, thus the symbol for the prism of the first order is $(10\bar{1}0)$ and that for the prism of the second order $(11\bar{2}0)$. In the case of pyramids of the second order where h equals k and i equals 2 h, the general expression becomes $(h.h.\bar{2}\bar{h}.1)$ in which $\frac{2h}{l}$ equals the coefficient of P2 in the corresponding Naumann symbol.

Goldschmidt's system of symbols. Goldschmidt in his *Index der Krystallformen der Mineralien* adopts three forms of symbols. Of these the first

---

This relation which is dependent on a geometrical property of the hexagon is universally true. It follows from the above that in the Bravais-Miller symbol for any hexagonal plane, the algebraic sum of the first and second indexes is equal to the third with the sign reversed.

is by far the one in most general use and is at present given by many of the German crystallographers in addition to the Naumann or Bravais-Miller symbols. This system of Goldschmidt consists of two indexes for every form, derived from the corresponding Bravais-Miller symbol by dividing the first and second indexes of the latter by the last index. Thus the general symbol $h\ k\ \bar{i}\ l$ of Bravais becomes $\frac{h}{l}\cdot\frac{k}{l}$ of Goldschmidt.

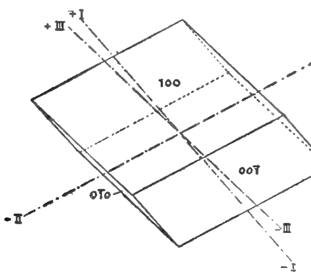


Fig. 17

Rhombohedral system of Miller. The system of symbols developed in 1839 by W. H. Miller[1] is, as applied to crystals of the rhombohedral division of the hexagonal system, largely used by the English and some of the German writers on crystallography. It is in fact the predecessor of the Bravais system which latter was derived from it. Miller refers rhombohedral-hexagonal crystals to three axes instead of four, the three Miller axes being parallel to the edges of the unit rhombohedron of the species. Figure 17 indicates the position of the Miller axes for the species calcite, the unit rhombohedron of which is shown with the Miller symbols for its respective planes. The indexes of the Miller symbol for any plane are derived from its intercepts on the three axes by a method analogous to that discussed under the Bravais system. The general type of Miller symbol is (h k l). These indexes are not susceptible of division into types as is the case with those of the Bravais system; for instance the Bravais symbol $(44\bar{8}3)$ conforming to the general type $(h.h.\overline{2h}.l)$ indicates a second order pyramid, whereas the corresponding Miller symbol (513) can not be referred to any such general type. Familiarity with the Miller symbols, however, develops certain characteristics by which forms geometrically related may be recognized. The principal advantage of the Miller system

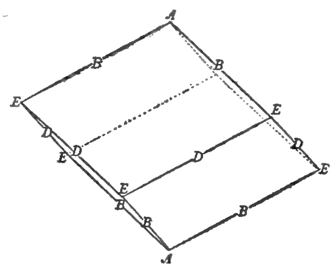


Fig. 18

[1] Miller, W. H. A Treatise on Crystallography. London 1839.

is that it provides a symbol of comparatively more simple indexes for the more important forms. Its principal disadvantage compared with the Bravais system consists in the failure of the Miller indexes to express the zonal relations to be discussed on page 33.

Lévy's system of symbols. The notation of A. Lévy [1] which is based upon the well known principle of the Abbé Haüy, is still used by French crystallographers. To develop the symbols of Lévy assume the unit rhombohedron lettered as in figure 18, that is the capital letters A, B, D and E are disposed on the angles and edges of the rhombohedron as follows:

The terminal solid angles are denoted by A
The terminal or polar edges are denoted by B
The lateral edges are denoted by D
The lateral solid angles are denoted by E

It is evident that the planes of every crystal form of calcite will truncate or bevel one of the elements. The Lévy symbol consists of one or more lower case letters corresponding to the edges or angle of the rhombohedron intersected by the plane of the form in combination with the rhombohedron, these letters being followed by figures placed as exponents which figures express the relative length of the edge or edges intercepted by the plane. The basal pinacoid shown in figure 2 which truncates the angle A and which intercepts equally the edges B is designated in the Lévy system by the symbol a^1. Similarly the prism of the first order [fig. 3] is designated by e^2 and the prism of the second order [fig. 4] which bevels the edge D is designated by d^1. Scalenohedrons having for the rhombohedron of the middle edges the unit rhombohedron, also bevel the edges D but since their initial planes intercept the edge B above at a greater distance than the edge B below the exponents of d in the Lévy symbols for these forms which express this ratio will be greater than one. Thus for the scalenohedron R3 (Naumann) the Lévy symbol is d^2 since the initial plane of R3 intercepts

[1] Lévy, A. Description d'une collection de mineraux formée par M. H. Heuland. London 1837.

the edge B above at a distance from E twice that of the intercept on B below.

The negative rhombohedron $-\frac{1}{2}R$ shown in figure 11 and which bevels the B edges of the unit rhombohedron is designated in Lévy's notation as b^1. A negative rhombohedron more obtuse than $-\frac{1}{2}R$ would incline toward A and would be indicated by the symbol a with a fractional exponent less than 1 since a^1 represents the basal pinacoid.

Continuing along the same line the positive rhombohedrons having an inclination between the basal pinacoid and the unit rhombohedron, that is those having a coefficient of R (Naumann) which is less than 1, would be indicated in Lévy's notation by a with an exponent greater than 1. Similarly negative rhombohedrons having a steeper inclination than R are represented in the Lévy symbols by e with varying exponents. Positive rhombohedrons are called in this notation *Rhomboedres directs* and negative rhombohedrons *Rhomboedres inverses.* Scalenohedrons which bevel the edges B are indicated by b with an exponent greater than 1 and scalenohedrons which truncate the angles E in such a way that the intersections on the edge B and on one of the edges D measured from E are equal, are indicated by e with an exponent greater or less than 1. For other scalenohedrons, that is for those whose intersections on the three intersecting edges are unequal, the general symbols $b^{\frac{1}{h}}\ b^{\frac{1}{k}}\ b^{\frac{1}{l}}$, $b^{\frac{1}{h}}\ b^{\frac{1}{k}}\ d^{\frac{1}{l}}$ and $d^{\frac{1}{h}}\ d^{\frac{1}{k}}\ b^{\frac{1}{l}}$ apply, the exponents $\frac{1}{h}$, $\frac{1}{k}$ and $\frac{1}{l}$ being the corresponding Miller indexes for the form. In general, since the edges of the unit rhombohedron are parallel to the Miller axes the exponents of the Lévy symbols are the reciprocals of the corresponding Miller indexes.

In many of the older papers on the crystallization of calcite a system of notation devised by F. Mohs[1] is employed. This system is now obsolete but inasmuch as many of these papers are of value as touching the early recognition of well known forms, the symbols of Mohs are given in correlation with those of Naumann, Bravais, Miller and Lévy in the table on pages 38–50.

[1] Mohs, F. Grundriss der Mineralogie. Dresden 1822–24.

Zonal relations. Examination of a suite of crystals of any crystallized mineral will render apparent the fact that certain planes in combination are so related that the series of their intersecting edges are parallel. Such a series of faces are said to lie in a zone.[1] Thus in figure 18 the edges B and D are parallel in three series, corresponding to the three Miller axes which in this case are zone axes, and consequently the faces of the unit rhombohedron lie in three zones each composed of four faces. The crystal of calcite illustrated in figure 19, the faces of which are designated by the Bravais symbols, shows three well developed series of zones, viz:

1 The series having its edges parallel to the rhombohedron R ($10\bar{1}1$) and including the faces $4\bar{1}35$, $10\bar{1}1$, $31\bar{4}2$, $21\bar{3}1$, $11\bar{2}0$ etc.

2 The series having its edges parallel to —2R ($02\bar{2}1$) [*see* fig. 10] and including the faces $02\bar{2}1$, $24\bar{6}1$, $11\bar{2}0$, $42\bar{6}\bar{1}$, $20\bar{2}\bar{1}$ etc.

3 The series having its edges parallel to the short polar edges of R3 ($21\bar{3}1$) [*see* fig. 16] and including $21\bar{3}1$, $02\bar{2}1$, $\bar{2}3\bar{1}1$ etc.

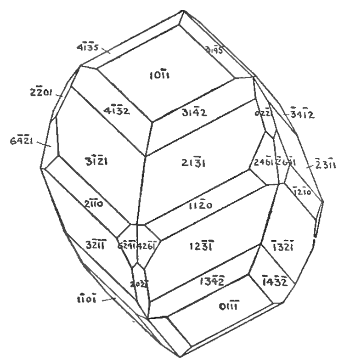


Fig. 19

Each of these zones indicated is, by reason of the fundamental symmetry of the crystallographic group to which calcite belongs, repeated three times. Thus the zone [$10\bar{1}1.11\bar{2}0$] corresponds to [$10\bar{1}1.2\bar{1}\bar{1}0$] and to [$01\bar{1}\bar{1}.\bar{1}2\bar{1}0$].

Any zone is determined by the direction of the intersecting edges of its planes and consequently by the direction with respect to the crystallographic axes of a line parallel to these edges and passing through the center of the crystal. Such a line is called the zone axis. The indexes which fix the position of the zone axis may be derived from the Bravais symbols of two planes in its zone by the following method:

[1] The conception of a crystal encircled by a zone may be facilitated by the consideration of figure 5 which shows the fundamental rhombohedron intersected by the planes of the prism of the second order. The six planes of the latter form lie in a vertical zone.

The Bravais symbols ($h\ k\ \bar{i}\ l$) and ($h'\ k'\ \bar{i}'\ l'$) of the two faces from which the indexes i and i' are omitted are written twice over one another as represented thus:

$$\begin{array}{c|cccc|c} h & k & l & h & k & l \\ & & \times & \times & \times & \\ h' & k' & l' & h' & k' & l' \end{array}$$

The four end indexes are struck out and the remaining indexes are multiplied and subtracted as follows:

$$h\,l' - l\,k' = u$$
$$l\,h' - h\,l' = v$$
$$h\,k' - k\,h' = w$$

The resulting numbers [u v w] inclosed in brackets gives the symbol for the zone axis. The above operation of cross multiplication is much simplified by reading the products from left to right downward for the first term and from right to left downward for the second term of each equation. Strict attention should be paid to signs the results being *algebraic* products, sums and differences. Referring for a concrete example to figure 19 the zone symbol for the zone containing the faces $10\bar{1}1$ and $11\bar{2}0$ is

$$\begin{array}{c|cccc|c} 1 & 0 & 1 & 1 & 0 & 1 \\ & & \times & \times & \times & \\ 1 & 1 & 0 & 1 & 1 & 0 \end{array}$$

$$(0 - 1)\ \ (1 - 0)\ \ (1 - 0) = [\bar{1}11]$$

Also the zone symbol for the zone containing $24\bar{6}1$ and $42\bar{6}\bar{1}$ is

$$\begin{array}{c|cccc|c} 2 & 4 & 1 & 2 & 4 & 1 \\ & & \times & \times & \times & \\ 4 & 2 & \bar{1} & 4 & 2 & \bar{1} \end{array}$$

$$(-4 - 2)\ \ (4 + 2)\ \ (4 - 16) = [\bar{6}.6.\overline{12}]$$

or dividing this ratio through by 6, $[\bar{1}1\bar{2}]$.

It has been demonstrated[1] that the algebraic sum of the (h k l) indexes of any face in a given zone multiplied by the corresponding indexes [u v w] of the zone symbol is equal to 0;

$$h\,u + k\,v + l\,w = 0$$

[1] Miller, W. H. A Treatise on Crystallography. London 1839. p. 10.

Turning again for a concrete example to figure 19, the indexes of the face $31\bar{4}2$ which lies in the zone $[10\bar{1}1.11\bar{2}0]$ when multiplied by the zone symbol $[\bar{1}11]$ give the equation

$$(3\,\mathrm{x} - 1) + (1\,\mathrm{x}\,1) + (2\,\mathrm{x}\,1) = 0$$
$$-3 + 1 + 2 = 0$$

The same relation may be verified for any face in the zone $[10\bar{1}1.11\bar{2}0]$.

Applying this principle to the faces $4\bar{1}\bar{3}2$, $21\bar{3}1$, and $24\bar{6}1$ in figure 19, it will be found that these three planes are also in zone, a fact not at first apparent from the figure. Thus:

$$\begin{array}{c|cccc|c} 2 & 1 & 1 & 2 & 1 & 1 \\ & & \mathrm{x} & \mathrm{x} & \mathrm{x} & \\ 2 & 4 & 1 & 2 & 4 & 1 \\ \hline \end{array}$$
$$(1-4)\ (2-2)\ (8-2) = [\bar{3}06]$$

and

$$(4\,\mathrm{x} - 3) + (-1\,\mathrm{x}\,0) + (2\,\mathrm{x}\,6) = -12 + 12 = 0$$

This principle is highly useful in the study of crystal forms inasmuch as the forms occurring in zones show marked tendency to enter into crystal combination with each other.

The indexes of a face occurring in two zones are obtained by cross multiplying the zone symbols of both zones. Taking again for a concrete example figure 19, the face $02\bar{2}1$ lies in the zone $[21\bar{3}1.\bar{2}3\bar{1}1]$ and also in the zone $[24\bar{6}1.11\bar{2}0]$. Its indexes can therefore be verified by cross multiplying the zone symbols of these two zones.

$$\begin{array}{c|cccc|c} 2 & 1 & 1 & 2 & 1 & 1 \\ & & \mathrm{x} & \mathrm{x} & \mathrm{x} & \\ \bar{2} & 3 & 1 & \bar{2} & 3 & 1 \\ \hline \end{array}$$
$$\bar{2}\ \bar{4}\ 8 = \bar{1}\ \bar{2}\ 4$$

$$\begin{array}{c|cccc|c} 2 & 4 & 1 & 2 & 4 & 1 \\ & & \mathrm{x} & \mathrm{x} & \mathrm{x} & \\ 1 & 1 & 0 & 1 & 1 & 0 \\ \hline \end{array}$$
$$\bar{1}\ 1\ \bar{2}$$

$$\begin{array}{c|cccc|c} \bar{1} & \bar{2} & 4 & \bar{1} & \bar{2} & 4 \\ & & \mathrm{x} & \mathrm{x} & \mathrm{x} & \\ \bar{1} & 1 & \bar{2} & \bar{1} & 1 & \bar{2} \\ \hline \end{array}$$
$$0\ \bar{6}\ \bar{3}$$

Or dividing this ratio by -3 and supplying the third term, $02\bar{2}1$.

System of lettering forms. Although the system of symbols hitherto described are essential to the expression of the relations between crystal forms of calcite, they are, particularly in the case of the Bravais indexes, cumbersome when applied to the designation of faces in crystal drawings. Extending back to the early literature of calcite the universal custom among crystallographers has been to assign a letter to each crystal form. As new forms were recorded and corresponding letters assigned to them this letter system soon outgrew the limits of the Roman letters, and Greek and German letters were resorted to. Some of the early writers introduced astronomic and alchemistic characters, and the French crystallographers for the most part lettered their figures with the Lévy symbols. These letters were assigned with no regard to the crystallographic relation of the forms and were in many instances duplicated or, as in the case of the unit rhombohedron, the form was indicated by several different letters. Dr V. Goldschmidt[1] to obviate this confusion and to provide a rational and universal method has devised a system at once simple and comprehensive for lettering the forms of calcite. His scheme of lettering, which admits of considerable expansion to provide for the recording of new forms, employs the large and small letters of the Roman, Greek and German type, omitting certain letters which, from their similarity to others employed, would lead to confusion. In this way 133 characters are available. This number is, however, insufficient for the lettering of the upward of 300 recognized forms of calcite. Goldschmidt meets this difficulty by introducing a period, colon and a diacritical mark consisting of three vertical dots after the letters, thus increasing the number of available characters fourfold. These are assigned to the types of forms as follows:

1 Prisms, pinacoids and pyramids of the second order are lettered with plain small Roman and Greek letters, thus *a*, α.

2 Rhombohedrons are lettered with large and small Roman and Greek letters followed by a period, thus: A., a., Δ., δ..

[1] Goldschmidt, V. Index der Krystallformen der Mineralien. Berlin 1886. 1:134, 141.

3 Scalenohedrons in the zone of the fundamental rhombohedron $[10\bar{1}1.11\bar{2}0]$ are lettered with Roman and Greek letters followed by a colon, thus A:, a:, Δ:, ∂:.

4 Scalenohedrons in the rhombohedral zones $[02\bar{2}1.11\bar{2}0]$, $[40\bar{4}1.11\bar{2}0]$, $[05\bar{5}1.11\bar{2}0]$, $[08\bar{8}1.11\bar{2}0]$, $[70\bar{7}1.11\bar{2}0]$, $[01\bar{1}2.11\bar{2}0]$, $[10.0.\bar{10}.1.11\bar{2}0]$ and $[10\bar{1}4.11\bar{2}0]$ are lettered with Roman, Greek and German letters followed by a diacritical mark consisting of three vertical dots, thus A⁝, a⁝, Δ⁝, ∂⁝, 𝔄⁝, 𝔞⁝.

5 All other scalenohedrons are lettered with plain Roman, Greek and German letters, thus A, Δ, 𝔄.

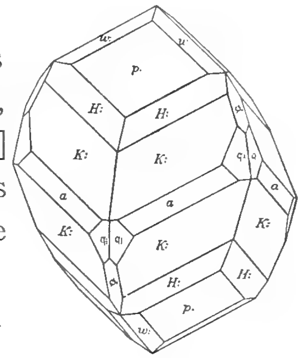


Fig. 20

Figure 20 shows the combination of forms illustrated in figure 19 lettered according to Goldschmidt's method which will be henceforth used throughout this work.

LIST OF FORMS OF CALCITE

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	MILLER SYMBOL	LÉVY SYMBOL	MOHS SYMBOL	LOCALITY	AUTHOR AND DATE
o	0R	0001	111	a^1	$R-\infty$	....	Haüy. 1801
a	$\infty P2$	$11\bar{2}0$	$10\bar{1}$	d^1	$P-\infty$	....	Haüy. 1801
b	∞R	$10\bar{1}0$	$2\bar{1}\bar{1}$	e^2	$R+\infty$	....	Haüy. 1801
				DIHEXAGONAL PRISMS			
ψ	$\infty R\frac{11}{9}$	$10.1.\bar{11}.0$	$73\bar{4}$	$d^{\frac{1}{4}}\, d^{\frac{1}{3}}\, b^{\frac{1}{7}}$	....	Neumark............	Schnorr. 1896
σ	$\infty R\frac{4}{3}$	$71\bar{8}0$	$52\bar{3}$	$d^{\frac{1}{3}}\, d^{\frac{1}{2}}\, b^{\frac{1}{5}}$	....	Bergen Hill, N. J......	Whitlock. 1909
ς	$\infty R2$	$31\bar{4}0$	$72\bar{5}$	$d^{\frac{1}{5}}\, d^{\frac{1}{2}}\, b^{\frac{1}{7}}$	$(P+\infty)^2$	....	Haüy. 1822
θ	$\infty R3$	$21\bar{3}0$	$51\bar{4}$	$d^{\frac{1}{4}}\, d^1\, b^{\frac{1}{5}}$	$(P+\infty)^3$	....	Bournon. 1808
μ	$\infty R4$	$53\bar{8}0$	$13.\bar{2}.\bar{11}$	$d^{\frac{1}{11}} d^{\frac{1}{2}}\, b^{\frac{1}{13}}$	....	Smith's Basin.........	Whitlock. 1910
j	$\infty R13$	$7.6.\bar{13}.0$	$20.\bar{1}.\bar{19}$	$d^{\frac{1}{10}} d^1\, b^{\frac{1}{20}}$	....	Andreasberg..........	Schaller. 1908
				PYRAMIDS OF THE SECOND ORDER			
π	$\frac{2}{3}P2$	$11\bar{2}3$	210	b^2	P	Derbyshire...........	Haüy. 1822
χ	$\frac{7}{6}P2$	$7.7.\bar{14}.12$	$11.4.\bar{3}$	$d^{\frac{1}{11}} d^{\frac{1}{4}}\, b^{\frac{1}{3}}$	$\frac{7}{4}P$	Derbyshire...........	Haüy. 1822
λ	$\frac{4}{3}P2$	$22\bar{4}3$	$31\bar{1}$	e_3	2P	....	Lévy. 1837
υ	2P2	$11\bar{2}1$	$41\bar{2}$	$d^{\frac{1}{4}}\, d^1\, b^{\frac{1}{2}}$	....	Lake Superior.........	Palache. 1900
α	$\frac{8}{3}P2$	$44\bar{8}3$	$51\bar{3}$	$d^{\frac{1}{5}}\, d^1\, b^{\frac{1}{3}}$	P+2	....	Mohs. 1839
ω	$\frac{32}{9}P2$	$16.16.\bar{32}.9$	$19.3.\bar{13}$	$d^{\frac{1}{19}} d^{\frac{1}{3}}\, b^{\frac{1}{13}}$	....	Lake Superior.........	Palache. 1900
ξ	4P2	$22\bar{4}1$	$71\bar{5}$	$d^{\frac{1}{7}}\, d^1\, b^{\frac{1}{5}}$	$\frac{3}{2}P+2$	....	Haüy. 1822
β	$\frac{14}{3}P2$	$7.7.\bar{14}.3$	$81\bar{6}$	$d^{\frac{1}{8}}\, d^1\, b^{\frac{1}{6}}$	7P	....	Zippe. 1852
γ	$\frac{16}{3}P2$	$8.8.\bar{16}.3$	$91\bar{7}$	$d^{\frac{1}{9}}\, d^1\, b^{\frac{1}{7}}$	P+3	....	Bournon. 1808
δ	6P2	$33\bar{6}1$	$10.1.\bar{8}$	$d^{\frac{1}{10}} d^1\, b^{\frac{1}{8}}$	9P	....	Haüy. 1822
ε	8P2	$44\bar{8}1$	$13.1.\bar{11}$	$d^{\frac{1}{13}} d^1\, b^{\frac{1}{11}}$	3P+2	Andreasberg..........	Zippe. 1852
η	10P2	$5.5.\bar{10}.1$	$16.1.\bar{14}$	$d^{\frac{1}{16}} d^1\, b^{\frac{1}{14}}$	....	Frizington............	Rogers. 1901
φ	16P2	$8.8.\bar{16}.1$	$25.1.\bar{23}$	$d^{\frac{1}{25}} d^1\, b^{\frac{1}{23}}$	....	Sommerville..........	Whitlock. 1910
				POSITIVE RHOMBOHEDRONS			
z.	28R	$28.0.\bar{28}.1$	$19.\bar{9}.\bar{9}$	$e^{\frac{19}{9}}$	$\frac{7}{4}R+4$	Alston Moor..........	Zippe. 1852
j.	25R	$25.0.\bar{25}.1$	$17.\bar{8}.\bar{8}$	$e^{\frac{17}{8}}$	....	Matlock..............	Bodewig. 1878
c.	24R	$24.0.\bar{24}.1$	$49.\bar{23}.\bar{23}$	$e^{\frac{49}{23}}$	....	Wisconsin............	Hobbs. 1895
Z.	22R	$22.0.\bar{22}.1$	$15.\bar{7}.\bar{7}$	$e^{\frac{15}{7}}$	....	Badenweiles..........	Sansoni. 1890
i.	20R	$20.0.\bar{20}.1$	$41.\bar{19}.\bar{19}$	$e^{\frac{41}{19}}$	....	St Blasien............	Sansoni. 1890

u.	19R	$19.0.\bar{19}.1$	$13.\bar{6}.\bar{6}$	$e^{\frac{13}{6}}$	....	....	Goldschmidt. 1886
v.	18R	$18.0.\bar{18}.1$	$37.\bar{17}.\bar{17}$	$e^{\frac{37}{17}}$	....	Arlberg..............	Foullon. 1885
t.	16R	$16.0.\bar{16}.1$	$11.\bar{5}.\bar{5}$	$e^{\frac{11}{5}}$	R + 4	Derbyshire...........	Zippe. 1852
s.	13R	$13.0.\bar{13}.1$	$9\bar{4}\bar{4}$	$e^{\frac{9}{4}}$	13R	....	Haüy. 1801
k.	11R	$11.0.\bar{11}.1$	$23.\bar{10}.\bar{10}$	$e^{\frac{23}{10}}$	....	Andreasberg..........	Thürling. 1885
r.	10R	$10.0.\bar{10}.1$	$7\bar{3}\bar{3}$	$e^{\frac{7}{3}}$	....	Iceland..............	Hessenberg. 1873
b.	9R	$90\bar{9}1$	$19.\bar{8}.\bar{8}$	$e^{\frac{19}{8}}$	....	Iceland..............	Hessenberg. 1866
c.	8R	$80\bar{8}1$	$17.\bar{7}.\bar{7}$	$e^{\frac{17}{7}}$	....	Rhisnes..............	Cesàro. 1889
q.	7R	$70\bar{7}1$	$5\bar{2}\bar{2}$	$e^{\frac{5}{2}}$	$\frac{7}{4}R+2$	....	Haüy. 1822
x.	$\frac{13}{2}R$	$13.0.\bar{13}.2$	$28.\bar{11}.\bar{11}$	$e^{\frac{28}{11}}$	....	Rauris...............	Höfer. 1891
y.	6R	$60\bar{6}1$	$13.\bar{5}.\bar{5}$	$e^{\frac{13}{5}}$	....	Traversella..........	Sella. 1856
o.	$\frac{11}{2}R$	$11.0.\bar{11}.2$	$8\bar{3}\bar{3}$	$e^{\frac{8}{3}}$	....	....	Lévy. 1837
n.	5R	$50\bar{5}1$	$4.4.\bar{11}$	$e^{\frac{11}{4}}$	....	Derbyshire...........	Bournon. 1808
m.	4R	$40\bar{4}1$	$11\bar{3}$	e^3	R + 2	....	Haüy. 1822
l.	3R	$30\bar{3}1$	$22\bar{7}$	$e^{\frac{7}{2}}$	$\frac{3}{4}R+2$	Traversella..........	Sella. 1856
K.	$\frac{5}{2}R$	$50\bar{5}2$	$11\bar{4}$	e^4	$\frac{5}{8}R+2$	Derbyshire...........	Bournon. 1808
R.	2R	$20\bar{2}1$	$11\bar{5}$	e^5	....	Lake Superior........	Palache. 1900
p.	R	$10\bar{1}1$	100	p	R	....	Haüy. 1801
V.	$\frac{4}{5}R$	$40\bar{4}5$	13.1.1	a^{13}	....	Joplin...............	Sterrett. 1904
h.	$\frac{2}{3}R$	$20\bar{2}3$	711	a^7	$-\frac{1}{3}R+1$	....	Lévy. 1837
g.	$\frac{4}{7}R$	$40\bar{4}7$	511	a^5	....	Maderaner Thal.......	Hessenberg. 1860
f.	$\frac{1}{2}R$	$10\bar{1}2$	411	a^4	$-R-1$	....	Lévy. 1837
e.	$\frac{2}{5}R$	$20\bar{2}5$	311	a^3	$\frac{2}{5}R$	Maderaner Thal.......	Hessenberg. 1860
d.	$\frac{1}{4}R$	$10\bar{1}4$	211	a^2	R − 2	Hartz................	Bournon. 1808

NEGATIVE RHOMBOHEDRONS

α.	$-\frac{1}{5}R$	$01\bar{1}5$	221	$a^{\frac{1}{2}}$	$\frac{2}{5}R-1$	....	Haüy. 1822
β.	$-\frac{7}{20}R$	$0.7.\bar{7}.20$	992	$a^{\frac{2}{9}}$	....	Offenbanya...........	Lévy. 1837
γ.	$-\frac{2}{5}R$	$02\bar{2}5$	771	$a^{\frac{1}{7}}$	$\frac{4}{5}R-1$	Hartz................	Bournon. 1808
δ.	$-\frac{1}{2}R$	$01\bar{1}2$	110	b^1	R − 1	....	Haüy. 1822
a.	$-\frac{11}{20}R$	$0.11.\bar{11}.20$	$31.31.\bar{2}$	$e^{\frac{2}{31}}$	....	Wisconsin............	Hobbs. 1895..
ε.	$-\frac{3}{5}R$	$03\bar{3}5$	$88\bar{1}$	$e^{\frac{1}{8}}$	$\frac{6}{5}R-1$	Derbyshire...........	Bournon. 1808
ς.	$-\frac{2}{3}R$	$02\bar{2}3$	$55\bar{1}$	$e^{\frac{1}{5}}$	$\frac{4}{3}R-1$	....	Hausmann. 1847
b.	$-\frac{18}{25}R$	$0.18.\bar{18}.25$	$43.43.\bar{11}$	$e^{\frac{11}{43}}$	....	Wisconsin............	Hobbs. 1895
S.	$-\frac{11}{14}R$	$0.11.\bar{11}.14$	$25.25.\bar{8}$	$e^{\frac{8}{25}}$	....	Münsterthal..........	Sansoni. 1890
η.	$-\frac{4}{5}R$	$04\bar{4}5$	$33\bar{1}$	$e^{\frac{1}{3}}$	$\frac{2}{5}R+1$	Dauphiné.............	Bournon. 1808
ϑ.	$-\frac{14}{17}R$	$0.14.\bar{14}.17$	$31.31.\bar{11}$	$e^{\frac{11}{31}}$	....	New Mexico...........	Schaller. 1908
θ.	$-\frac{7}{8}R$	$07\bar{7}8$	$55\bar{2}$	$e^{\frac{2}{5}}$	$\frac{7}{4}R-1$	Maxen, Saxony........	Lévy. 1837
D.	$-\frac{19}{20}R$	$0.19.\bar{19}.20$	$13.13.\bar{6}$	$e^{\frac{6}{13}}$	....	Arquennes............	Cesàro. 1889
ϰ.	−R	$01\bar{1}1$	$22\bar{1}$	$e^{\frac{1}{2}}$	−R	....	Haüy. 1822

LIST OF FORMS *(continued)*

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	MILLER SYMBOL	LÉVY SYMBOL	MOHS SYMBOL	LOCALITY	AUTHOR AND DATE
$\mathfrak{h}$.	$-\frac{17}{16}R$	$0.17.\bar{17}.16$	$11.11.\bar{6}$	$e^{\frac{6}{11}}$	....	Rhisnes	Cesàro. 1889
λ.	$-\frac{8}{7}R$	$08\bar{8}7$	$55\bar{3}$	$e^{\frac{3}{5}}$	$\frac{4}{7}R+1$	Andreasberg	Zippe. 1851
μ.	$-\frac{6}{5}R$	$06\bar{6}5$	$11.11.\bar{7}$	$e^{\frac{7}{11}}$	$\frac{3}{5}R+1$	Andreasberg	Naumann. 1828
ν.	$-\frac{5}{4}R$	$05\bar{5}4$	$33\bar{2}$	$e^{\frac{2}{3}}$	$\frac{5}{8}R+1$	Siberia	Bournon. 1808
G.	$-\frac{14}{11}R$	$0.14.\bar{14}.11$	$25.25.\bar{17}$	$e^{\frac{17}{25}}$	....	Norberg	Johansson. 1892
ξ.	$-\frac{4}{3}R$	$04\bar{4}3$	$77\bar{5}$	$e^{\frac{5}{7}}$	....	Canarie Islands	Hessenberg. 1870
H.	$-\frac{18}{13}R$	$0.18.\bar{18}.13$	$31.31.\bar{23}$	$e^{\frac{23}{31}}$	....	New Jersey	Rogers. 1902
π.	$-\frac{7}{5}R$	$07\bar{7}5$	$44\bar{3}$	$e^{\frac{3}{4}}$	$\frac{7}{10}R+1$	....	Weiss. 1836
P.	$-\frac{13}{9}R$	$0.13.\bar{13}.9$	$22.22.\bar{17}$	$e^{\frac{17}{22}}$	....	Andreasberg	Sansoni. 1884
Y.	$-\frac{19}{13}R$	$0.19.\bar{19}.13$	$32.32.\bar{25}$	$e^{\frac{25}{32}}$	....	Lyon Mountain	Whitlock. 1907
ρ.	$-\frac{3}{2}R$	$03\bar{3}2$	$55\bar{4}$	$e^{\frac{4}{5}}$	$\frac{3}{4}R+1$	....	Haüy. 1822
σ.	$-\frac{11}{7}R$	$0.11.\bar{11}.7$	$66\bar{5}$	$e^{\frac{5}{6}}$	$\frac{11}{14}R+1$	Alston Moor	Zippe. 1851
$\mathfrak{f}$.	$-\frac{8}{5}R$	$08\bar{8}5$	$13.13.\bar{11}$	$e^{\frac{11}{13}}$	....	Narsarsuk	Flink. 1899
τ.	$-\frac{13}{8}R$	$0.13.\bar{13}.8$	$77\bar{6}$	$e^{\frac{6}{7}}$	$13R-3$	....	Bournon. 1808
L.	$-\frac{5}{3}R$	$05\bar{5}3$	$88\bar{7}$	$e^{\frac{7}{8}}$	....	Andreasberg	Thürling. 1885
M.	$-\frac{7}{4}R$	$07\bar{7}4$	$11.11.\bar{10}$	$e^{\frac{10}{11}}$	....	Andreasberg	Thürling. 1885
A.	$-\frac{9}{5}R$	$09\bar{9}5$	$14.14.\bar{13}$	$e^{\frac{13}{14}}$	....	Andreasberg	Sansoni. 1884
N.	$-\frac{11}{6}R$	$0.11.\bar{11}.6$	$17.17.\bar{16}$	$e^{\frac{16}{17}}$	....	Andreasberg	Thürling. 1885
φ.	$-2R$	$02\bar{2}1$	$11\bar{1}$	e^{1}	$R+1$	Hüttenberg	Haüy. 1801
χ.	$-\frac{9}{4}R$	$09\bar{9}4$	$13.13.\bar{14}$	$e^{\frac{14}{13}}$	$\frac{9}{2}R-1$	Cumberland	Bournon. 1808
F.	$-\frac{12}{5}R$	$0.12.\bar{12}.5$	$17.17.\bar{19}$	$e^{\frac{19}{17}}$	....	....	Des Cloizeaux. 1874
ψ.	$-\frac{5}{2}R$	$05\bar{5}2$	$77\bar{8}$	$e^{\frac{8}{7}}$	$-\frac{5}{8}R+2$	Andreasberg	Zippe. 1852
ω.	$-\frac{11}{4}R$	$0.11.\bar{11}.4$	$55\bar{6}$	$e^{\frac{6}{5}}$	$\frac{11}{2}R-1$	Derbyshire	Bournon. 1808
Γ.	$-3R$	$03\bar{3}1$	$44\bar{5}$	$e^{\frac{5}{4}}$	$\frac{3}{2}R+1$	Derbyshire	Bournon. 1808
$\mathfrak{g}$.	$-\frac{16}{5}R$	$0.16.\bar{16}.5$	$77\bar{9}$	$e^{\frac{9}{7}}$	....	Budapest	Melczer. 1896
J.	$-\frac{13}{4}R$	$0.13.\bar{13}.4$	$17.17.\bar{22}$	$e^{\frac{22}{17}}$	....	New Jersey	Rogers. 1902
Δ.	$-\frac{7}{2}R$	$07\bar{7}2$	$33\bar{4}$	$e^{\frac{4}{3}}$	$\frac{7}{4}R+1$	Derbyshire	Bournon. 1808
Θ.	$-4R$	$04\bar{4}1$	$55\bar{7}$	$e^{\frac{7}{5}}$	$-R+2$	....	Haüy. 1822
Λ.	$-\frac{9}{2}R$	$09\bar{9}2$	$11.11.\bar{16}$	$e^{\frac{16}{11}}$	....	Andreasberg	vom Rath
Ξ.	$-5R$	$05\bar{5}1$	$22\bar{3}$	$e^{\frac{3}{2}}$	$\frac{5}{8}R+3$	Derbyshire	Haüy. 1822
Q.	$-7R$	$07\bar{7}1$	$8.8.\bar{13}$	$e^{\frac{13}{8}}$	....	Rondout	Whitlock. 1910

Π.	$-8R$	$08\bar{8}1$	$33\bar{5}$	$e^{\frac{5}{3}}$	$R+3$	....	Haüy. 1822
B.	$-9R$	$09\bar{9}1$	$10.10.\overline{17}$	$e^{\frac{17}{10}}$	....	Andreasberg..........	Sansoni. 1884
						Kongsberg............	Morton. 1884
Σ.	$-11R$	$0.11.\overline{11}.1$	$44\bar{7}$	$e^{\frac{7}{4}}$	$\frac{11}{2}R+1$	Traversella...........	Sella. 1856
C.	$-13R$	$0.13.\overline{13}.1$	$14.14.\overline{25}$	$e^{\frac{25}{14}}$	....	Reuris...............	Höfer. 1891
Φ.	$-14R$	$0.14.\overline{14}.1$	$55\bar{9}$	$e^{\frac{9}{5}}$	$\frac{7}{4}R+3$	....	Haüy. 1801
Ψ.	$-17R$	$0.17.\overline{17}.1$	$6.6.\overline{11}$	$e^{\frac{11}{6}}$	....	....	Des Cloizeaux. 1874
Ω.	$-20R$	$0.20.\overline{20}.1$	$7.7.\overline{13}$	$e^{\frac{13}{7}}$	....	Joplin................	Farrington. 1900
T.	$-28R$	$0.28.\overline{28}.1$	$29.29.\overline{55}$	$e^{\frac{55}{29}}$	....	Andreasberg..........	Thürling. 1885
U.	$-36R$	$0.36.\overline{36}.1$	$37.37.\overline{71}$	$e^{\frac{71}{37}}$	....	Norberg..............	Johansson. 1892
				SCALENOHEDRONS OF THE ZONE $[10\bar{1}1.11\bar{2}0]$			
ꝼ:	$-\frac{5}{13}R\frac{7}{5}$	$1.6.\bar{7}.13$	760	$b^{\frac{7}{6}}$	....	California.............	Schaller. 1908
h:	$-\frac{1}{3}R\frac{5}{3}$	$14\bar{5}9$	540	$b^{\frac{5}{4}}$	....	Körösmezö............	Moesz. 1897
i:	$-\frac{1}{6}R\frac{11}{3}$	$4.7.\overline{11}.18$	11.7.0	$b^{\frac{11}{7}}$	....	Körösmezö............	Moesz. 1897
z:	$-\frac{1}{5}R3$	$12\bar{3}5$	320	$b^{\frac{3}{2}}$	$(\frac{4}{5}P-2)^3$	Andreasberg..........	Bournon. 1808
u:	$-\frac{2}{13}R4$	$3.5.\bar{8}.13$	850	$b^{\frac{8}{5}}$	....	Lake Superior.........	Palache. 1900
y:	$-\frac{1}{8}R5$	$23\bar{5}8$	530	$b^{\frac{5}{3}}$	$(P-3)^5$	Strontian, Scotland....	Lévy. 1837
n:	$+\frac{4}{13}R\frac{5}{2}$	$7.3.\overline{10}.13$	10.3.0	$b^{\frac{10}{3}}$	....	Couzon...............	Gonnard. 1896
k:	$+\frac{1}{13}R9$	$5.4.\bar{9}.13$	940	$b^{\frac{9}{4}}$	....	Körösmezö............	Moesz. 1897
x:	$+\frac{1}{10}R7$	$4.3.\bar{7}.10$	730	$b^{\frac{7}{3}}$	$(\frac{2}{5}P-2)^7$	....	Haüy
l:	$+\frac{1}{7}R5$	$32\bar{5}7$	520	$b^{\frac{5}{2}}$	....	Bamle................	Morton. 1884
v:	$+\frac{1}{5}R\frac{11}{3}$	$7.4.\overline{11}.15$	11.4.0	$b^{\frac{11}{4}}$	....	Schneeberg...........	vom Rath. 1874
m:	$+\frac{5}{23}R\frac{17}{5}$	$11.6.17.23$	17.6.0	$b^{\frac{17}{6}}$	....	Couzon...............	Gonnard. 1896
t:	$+\frac{1}{4}R3$	$21\bar{3}4$	310	b^3	$(P-2)^3$	Derbyshire............	Bournon. 1808
ɧ:	$+\frac{2}{7}R\frac{8}{3}$	$11.5.\overline{16}.21$	16.5.0	$b^{\frac{16}{5}}$	....	Texas................	Schaller. 1908
g:	$+\frac{1}{3}R\frac{7}{3}$	$52\bar{7}9$	720	$b^{\frac{7}{2}}$	....	Sardinia..............	Sella. 1856
w:	$+\frac{2}{5}R2$	$31\bar{4}5$	410	b^4	$(\frac{2}{5}P)^2$	Derbyshire............	Bournon. 1808
f:	$+\frac{5}{11}R\frac{9}{5}$	$7.2.\bar{9}.11$	920	$b^{\frac{9}{2}}$	....	Bergen Hill...........	vom Rath. 1877
e:	$+\frac{1}{2}R\frac{5}{3}$	$41\bar{5}6$	510	b^5	$-(P-1)\frac{5}{3}$	St Pancraz	Zippe. 1852
o:	$+\frac{7}{13}R\frac{11}{7}$	$9.2.\overline{11}.13$	11.2.0	$b^{\frac{11}{2}}$	....	Budapest.............	Melczer. 1896
q:	$+\frac{4}{7}R\frac{3}{2}$	$51\bar{6}7$	610	b^6	$(\frac{4}{7}P)\frac{3}{2}$	Simplon..............	Bournon. 1808
α:	$+\frac{3}{5}R\frac{13}{9}$	$11.2.\overline{13}.15$	13.2.0	$b^{\frac{13}{2}}$	....	Andreasberg..........	Sansoni. 1884
c:	$+\frac{5}{8}R\frac{7}{5}$	$61\bar{7}8$	710	b^7	$(\frac{5}{8}P)\frac{7}{5}$	Andreasberg..........	Hausmann. 1847
b:	$+\frac{2}{3}R\frac{4}{3}$	$71\bar{8}9$	810	b^8	....	Sardinia..............	Sella. 1856
a:	$+\frac{7}{10}R\frac{9}{7}$	$8.1.\bar{9}.10$	910	b^9	$(\frac{7}{10}P)\frac{9}{7}$	Andreasberg..........	Zippe. 1852
β:	$+\frac{8}{11}R\frac{5}{4}$	$9.1.\overline{10}.11$	10.1.0	b^{10}	....	Andreasberg..........	Sansoni. 1884
d:	$+\frac{4}{5}R\frac{7}{6}$	$13.1.\overline{14}.15$	14.1.0	b^{14}	....	Nahe.................	vom Rath. 1868
A:	$+R\frac{6}{5}$	$11.1.\overline{12}.10$	$11.0.\bar{1}$	d^{11}	....	Bleiberg.............	Zepharovich. 1878
B:	$+R\frac{19}{15}$	$17.2.\overline{19}.15$	$17.0.\bar{2}$	$d^{\frac{17}{2}}$	....	Bleiberg.............	Zepharovich. 1878

LIST OF FORMS *(continued)*

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	MILLER SYMBOL	LÉVY SYMBOL	MOHS SYMBOL	LOCALITY	AUTHOR AND DATE
C:	$+R\frac{4}{3}$	$71\bar{8}6$	$70\bar{1}$	d^7	$(P)\frac{4}{3}$	Andreasberg	Hessenberg. 1875
γ:	$+R\frac{11}{8}$	$19.3.\overline{22}.16$	$19.0.\bar{3}$	$d^{\frac{19}{3}}$	....	Andreasberg	Sansoni. 1884
D:	$+R\frac{7}{5}$	$61\bar{7}5$	$60\bar{1}$	d^6	$(P)\frac{7}{5}$	Derbyshire	Bournon. 1808
E:	$+R\frac{3}{2}$	$51\bar{6}4$	$50\bar{1}$	d^5	$(P)\frac{3}{2}$	....	Haüy. 1822
I:	$+R\frac{8}{5}$	$13.3.\overline{16}.10$	$13.0.\bar{3}$	$d^{\frac{13}{3}}$	....	Andreasberg	Thürling. 1885
Z:	$+R\frac{13}{8}$	$21.5.\overline{26}.16$	$21.0.\bar{5}$	$d^{\frac{21}{5}}$	....	Neumark	Schnorr. 1896
F:	$+R\frac{5}{3}$	$41\bar{5}3$	$40\bar{1}$	d^4	$(P)\frac{5}{3}$	Derbyshire	Bournon. 1808
δ:	$+R\frac{12}{7}$	$19.5.\overline{24}.14$	$19.0.\bar{5}$	$d^{\frac{19}{5}}$	....	Andreasberg	Sansoni. 1884
μ:	$+R\frac{7}{4}$	$11.3.\overline{14}.8$	$11.0.\bar{3}$	$d^{\frac{11}{3}}$	....	Engis	Cesàro. 1886
G:	$+R\frac{9}{5}$	$72\bar{9}5$	$70\bar{2}$	$d^{\frac{7}{2}}$	....	Andreasberg	Lévy. 1837
λ:	$+R\frac{11}{6}$	$17.5.\overline{22}.12$	$17.0.\bar{5}$	$d^{\frac{17}{5}}$	....	New Jersey	Rogers. 1902
H:	$+R2$	$31\bar{4}2$	$30\bar{1}$	d^3	....	Hartz	Hausmann. 1847
J:	$+R\frac{7}{3}$	$52\bar{7}3$	$50\bar{2}$	$d^{\frac{5}{2}}$	....	Modena	Zippe. 1852
ξ:	$+R\frac{5}{2}$	$7.3.\overline{10}.4$	$70\bar{3}$	$d^{\frac{7}{3}}$	....	Montecatini	d'Archiardi. 1897
π:	$+R\frac{8}{3}$	$11.5.\overline{16}.6$	$11.0.\bar{5}$	$d^{\frac{11}{5}}$	....	Neumark	Schnorr. 1896
Ψ:	$+R\frac{11}{4}$	$15.7.\overline{22}.8$	$15.0.\bar{7}$	$d^{\frac{15}{7}}$	....	Neumark	Schnorr. 1896
K:	$+R3$	$21\bar{3}1$	$20\bar{1}$	d^2	$(P)^3$	....	Haüy. 1801
σ:	$+R\frac{31}{10}$	$41.21.\overline{62}.20$	$41.0.\overline{21}$	$d^{\frac{41}{21}}$	....	Schapbachthal	Sansoni. 1890
τ:	$+R\frac{19}{6}$	$25.13.\overline{38}.12$	$25.0.\overline{13}$	$d^{\frac{25}{13}}$	....	Schapbachthal	Sansoni. 1890
L:	$+R\frac{13}{4}$	$17.9.\overline{26}.8$	$17.0.\bar{9}$	$d^{\frac{17}{9}}$	$(P)\frac{13}{4}$	Lissnia	Zippe. 1852
ε:	$+R\frac{7}{2}$	$9.5.\overline{14}.4$	$90\bar{5}$	$d^{\frac{9}{5}}$	....	Andreasberg	Sansoni. 1884
M:	$+R\frac{11}{3}$	$7.4.\overline{11}.3$	$70\bar{4}$	$d^{\frac{7}{4}}$	$(P)\frac{11}{3}$	....	Haüy. 1801
φ:	$+R\frac{15}{4}$	$19.11.\overline{30}.8$	$19.0.\overline{11}$	$d^{\frac{19}{11}}$	....	Montecatini	Sansoni. 1888
χ:	$+R\frac{23}{6}$	$29.17.\overline{46}.12$	$29.0.\overline{17}$	$d^{\frac{29}{17}}$	....	Neumark	Schnorr. 1896
N:	$+R4$	$53\bar{8}2$	$50\bar{3}$	$d^{\frac{5}{3}}$	$(P)^4$	....	Lévy. 1837
O:	$+R\frac{13}{3}$	$8.5.\overline{13}.3$	$80\bar{5}$	$d^{\frac{8}{5}}$	$(P)\frac{13}{3}$	....	Zippe. 1852
p:	$+R\frac{14}{3}$	$17.11.\overline{28}.6$	$17.0.\overline{11}$	$d^{\frac{17}{11}}$	....	Lake Superior	Palache. 1900
P:	$+R5$	$32\bar{5}1$	$30\bar{2}$	$d^{\frac{3}{2}}$	$(P)^5$	....	Mohs. 1824
Q:	$+R\frac{16}{3}$	$19.13.\overline{32}.6$	$19.0.\overline{13}$	$d^{\frac{19}{13}}$	....	Andreasberg	Hessenberg. 1875
R:	$+R\frac{17}{3}$	$10.7.\overline{17}.3$	$10.0.\bar{7}$	$d^{\frac{10}{7}}$	$(P)\frac{17}{3}$	....	Hessenberg. 1860
ς:	$+R6$	$7.5.\overline{12}.2$	$70\bar{5}$	$d^{\frac{7}{5}}$	....	Andreasberg	Sansoni. 1884

S:	$+R\frac{19}{3}$	$11.8.\overline{19}.3$	$11.0.\overline{8}$	$d^{\frac{11}{8}}$	....	Andreasberg..........	vom Rath. 1867
η:	$+R\frac{20}{3}$	$23.17.\overline{40}.6$	$23.0.\overline{17}$	$d^{\frac{23}{17}}$	....	Andreasberg..........	Sansoni. 1884
s:	$+R\frac{15}{2}$	$17.13.\overline{30}.4$	$17.0.\overline{13}$	$d^{\frac{17}{13}}$	....	Plainfield, N. J........	Whitlock. 1909
T:	$+R7$	$43\overline{7}1$	$40\overline{3}$	$d^{\frac{4}{3}}$	$(P)^7$	Derbyshire...........	Bournon. 1808
θ:	$+R8$	$9.7.\overline{16}.2$	$90\overline{7}$	$d^{\frac{9}{7}}$	....	Andreasberg..........	Sansoni. 1884
U:	$+R9$	$54\overline{9}1$	$50\overline{4}$	$d^{\frac{5}{4}}$	$(P)^9$	Hartz, Derbyshire.....	Bournon. 1808
V:	$+R11$	$6.5.\overline{11}.1$	$60\overline{5}$	$d^{\frac{6}{5}}$	$(P)^{11}$	Faroe Islands.........	Haidinger. 1845
W:	$+R12$	$13.11.\overline{24}.2$	$13.0.\overline{11}$	$d^{\frac{13}{11}}$	$(P)^{12}$	Andreasberg..........	Naumann. 1826
X:	$+R13$	$7.6.\overline{13}.1$	$70\overline{6}$	$d^{\frac{7}{6}}$	$(P)^{13}$	Faroe Islands.........	Lévy. 1837
ω:	$+R14$	$15.13.\overline{28}.2$	$15.0.\overline{13}$	$d^{\frac{15}{13}}$	....	Framont.............	Stöber. 1892
ι:	$+R16$	$17.15.\overline{32}.2$	$17.0.\overline{15}$	$d^{\frac{17}{15}}$	....	Andreasberg..........	Sansoni. 1884
Y:	$+R17$	$9.8.\overline{17}.1$	$90\overline{8}$	$d^{\frac{9}{8}}$	....	Gestrikland...........	Sjögren. 1883
υ:	$+R19$	$10.9.\overline{19}.1$	$10.0.\overline{9}$	$d^{\frac{10}{9}}$	....	Montecatini...........	d'Archiardi. 1897
ϰ:	$+R20$	$21.19.\overline{40}.2$	$21.0.\overline{19}$	$d^{\frac{21}{19}}$	....	Arendal..............	Sansoni. 1890
SCALENOHEDRONS OF THE ZONE [$02\overline{2}1.\overline{1}2\overline{1}0$]							
$\mathfrak{v}$:	$+\frac{1}{2}R\frac{7}{3}$	$52\overline{7}6$	$61\overline{1}$	e_6	....	Körösmezö...........	Moesz. 1897
$\mathfrak{a}$:	$+\frac{2}{5}R3$	$42\overline{6}5$	$51\overline{1}$	e_5	$(\frac{2}{5}P)^3$	Derbyshire...........	Lévy. 1837
$\mathfrak{b}$:	$+\frac{1}{4}R5$	$32\overline{5}4$	$41\overline{1}$	e_4	$(P-2)^5$	l'Isère...............	Lévy. 1837
$\mathfrak{c}$:	$-\frac{1}{5}R7$	$34\overline{7}5$	$52\overline{2}$	$e_{\frac{5}{2}}$	$(\frac{2}{5}P-1)^7$	Andreasberg..........	Hausmann. 1847
$\mathfrak{d}$:	$-\frac{2}{7}R5$	$4.6.\overline{10}.7$	$73\overline{3}$	$e_{\frac{7}{3}}$	$(\frac{4}{7}P-1)^5$	Andreasberg..........	Hausmann. 1847
$\mathfrak{e}$:	$-\frac{1}{2}R3$	$12\overline{3}2$	$21\overline{1}$	e_2	$(P-1)^3$	Derbyshire...........	Lévy. 1837
$\mathfrak{f}$:	$-\frac{2}{3}R\frac{7}{3}$	$4.10.\overline{14}.9$	$95\overline{5}$	$e_{\frac{9}{5}}$	$-(\frac{2}{3}P)\frac{7}{3}$	Hartz................	Naumann. 1828
$\mathfrak{z}$:	$-\frac{4}{5}R2$	$26\overline{8}5$	$53\overline{3}$	$e_{\frac{5}{3}}$	....	Andreasberg..........	Sansoni. 1884
$\mathfrak{g}$:	$-R\frac{5}{3}$	$14\overline{5}3$	$32\overline{2}$	$e_{\frac{3}{2}}$	$-(P)\frac{5}{3}$	Andreasberg..........	Lévy. 1837
$\mathfrak{h}$:	$-\frac{8}{7}R\frac{3}{2}$	$2.10.\overline{12}.7$	$75\overline{5}$	$e_{\frac{7}{5}}$	....	Andreasberg..........	Wimmer. 1854
$\mathfrak{i}$:	$-\frac{5}{4}R\frac{7}{5}$	$16\overline{7}4$	$43\overline{3}$	$e_{\frac{4}{3}}$	$(\frac{5}{8}P+1)\frac{7}{5}$	Andreasberg..........	Lévy. 1837
$\mathfrak{k}$:	$-\frac{7}{5}R\frac{9}{7}$	$18\overline{9}5$	$54\overline{4}$	$e_{\frac{5}{4}}$	$(\frac{7}{10}P+1)\frac{9}{7}$	Striegau.............	Dufrenoy-Zippe. 1852
$\mathfrak{u}$:	$-\frac{3}{2}R\frac{11}{9}$	$1.10.\overline{11}.6$	$65\overline{5}$	$e_{\frac{6}{5}}$	....	Budapest.............	Melczer. 1896
$\mathfrak{m}$:	$-\frac{5}{3}R\frac{17}{15}$	$1.16.\overline{17}.9$	$98\overline{8}$	$e_{\frac{9}{8}}$	....	Derbyshire...........	Zippe. 1852
$\mathfrak{y}$:	$-2R\frac{4}{3}$	$17\overline{8}3$	$43\overline{4}$	$e_{\frac{3}{4}}$	....	Couzon..............	Gonnard. 1897
$\mathfrak{n}$:	$-2R\frac{3}{2}$	$15\overline{6}2$	$32\overline{3}$	$e_{\frac{2}{3}}$	$(P+1)\frac{3}{2}$	....	Lévy. 1837
$\mathfrak{o}$:	$-2R\frac{5}{3}$	$2.8.\overline{10}.3$	$53\overline{5}$	$e_{\frac{3}{5}}$	$(P+1)\frac{5}{3}$	Derbyshire...........	Bournon. 1808
$\mathfrak{p}$:	$-2R2$	$13\overline{4}1$	$21\overline{2}$	$e_{\frac{1}{2}}$	$(P+1)^2$	Derbyshire...........	Bournon. 1808
$\mathfrak{q}$:	$-2R3$	$24\overline{6}1$	$31\overline{3}$	$e_{\frac{1}{3}}$	$(P+1)^3$	Derbyshire...........	Bournon. 1808
$\mathfrak{t}$:	$-2R\frac{11}{3}$	$8.14.\overline{22}.3$	$11.3.\overline{11}$	$e_{\frac{3}{11}}$	....	Lyon Mountain........	Whitlock. 1910
$\mathfrak{r}$:	$-2R4$	$35\overline{8}1$	$41\overline{4}$	$e_{\frac{1}{4}}$	$(P+1)^4$	Derbyshire...........	Zippe. 1852
$\mathfrak{s}$:	$-2R5$	$4.6.\overline{10}.1$	$51\overline{5}$	$e_{\frac{1}{5}}$	....	Rossie...............	Whitlock. 1910
SCALENOHEDRONS OF THE ZONE [$50\overline{5}2.05\overline{5}1$]							
$\mathfrak{R}$:	$-\frac{5}{4}R3$	$5.10.\overline{15}.4$	$83\overline{7}$	$d^{\frac{1}{8}}\,d^{\frac{1}{3}}\,b^{\frac{1}{7}}$	....	Andreasberg..........	Sansoni. 1884

LIST OF FORMS (*continued*)

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	MILLER SYMBOL	LÉVY SYMBOL	MOHS SYMBOL	LOCALITY	AUTHOR AND DATE
				SCALENOHEDRONS OF THE ZONE $[40\bar{4}1.08\bar{8}1]$			
𝔘:	$+\frac{16}{7}R2$	$24.8.\overline{32}.7$	$21.\bar{3}.\overline{11}$	$d^{\frac{1}{11}}d^{\frac{1}{3}}b^{\frac{1}{21}}$	$(\frac{4}{7}P+2)^2$	Hartz	Lévy. 1837
U:	$+2R\frac{7}{3}$	$10.4.\overline{14}.3$	$9\bar{1}\bar{5}$	$d^{\frac{1}{5}}d^1b^{\frac{1}{9}}$	....	Lake Superior	Palache. 1900
𝔙:	$+\frac{8}{5}R3$	$16.8.\overline{24}.5$	$15.\bar{1}.\bar{9}$	$d^{\frac{1}{6}}d^1b^{\frac{1}{15}}$	$(\frac{2}{5}P+2)^3$	Arendal	Zippe. 1852
𝔜:	$+\frac{3}{2}R\frac{29}{9}$	$19.10.\overline{29}.6$	$18.\bar{1}.\overline{11}$	$d^{\frac{1}{11}}d^1b^{\frac{1}{18}}$	....	Rhisnes	Cesàro. 1889
𝔘	$+\frac{2}{3}R13$	$14.12.\overline{26}.5$	$15.\bar{1}.\overline{11}$	$d^{\frac{1}{11}}d^1b^{\frac{1}{15}}$	....	Lyon Mountain	Whitlock. 1907
𝔚:	$-\frac{5}{4}R\frac{23}{5}$	$9.14.\overline{23}.4$	$12.3.\overline{11}$	$d^{\frac{1}{12}}d^{\frac{1}{3}}b^{\frac{1}{11}}$	....	Nahe	vom Rath. 1868
𝔛:	$-4R\frac{5}{3}$	$4.16.\overline{20}.3$	$9.5.\overline{11}$	$d^{\frac{1}{9}}d^{\frac{1}{5}}b^{\frac{1}{11}}$	....	Iceland	Hessenberg. 1866
𝔏:	$-5R\frac{7}{5}$	$16\bar{7}1$	$32\bar{4}$	$d^{\frac{1}{3}}d^{\frac{1}{2}}b^{\frac{1}{4}}$	$(\frac{5}{8}P+3)\frac{7}{5}$	Westmorland	Lévy. 1837
ℨ:	$-8R\frac{5}{4}$	$1.9.\overline{10}.1$	$43\bar{6}$	$d^{\frac{1}{4}}d^{\frac{1}{3}}b^{\frac{1}{6}}$	$(P+3)\frac{5}{4}$	....	Zippe. 1852
				SCALENOHEDRONS OF THE ZONE $[70\bar{7}1.07\bar{7}2]$			
Q:	$-\frac{7}{3}R\frac{5}{3}$	$7.28.\overline{35}.9$	$17.10.\overline{18}$	$d^{\frac{1}{17}}d^{\frac{1}{10}}b^{\frac{1}{18}}$	....	Rödefiord	Hessenberg. 1873
V:	$-\frac{17}{13}R\frac{55}{17}$	$19.36.\overline{55}.13$	$29.10.\overline{26}$	$d^{\frac{1}{29}}d^{\frac{1}{10}}b^{\frac{1}{26}}$	....	Couzon	Gonnard. 1897
				SCALENOHEDRONS OF THE ZONE $[40\bar{4}1.0\bar{2}21]$			
𝔄:	$-\frac{3}{2}R\frac{13}{9}$	$2.11.\overline{13}.6$	$75\bar{6}$	$d^{\frac{1}{7}}d^{\frac{1}{5}}b^{\frac{1}{6}}$	....	Rhisnes	Cesàro. 1889
𝔒:	$-\frac{16}{11}R\frac{3}{2}$	$4.20.\overline{24}.11$	$39.37.\overline{34}$	$d^{\frac{1}{39}}d^{\frac{1}{37}}b^{\frac{1}{34}}$	....	Budapest	Melczer. 1896
𝔅:	$-\frac{7}{5}R\frac{11}{7}$	$2.9.\overline{11}.5$	$64\bar{5}$	$d^{\frac{1}{6}}d^{\frac{1}{4}}b^{\frac{1}{5}}$	....	Sardinia	Sella. 1856
𝔔:	$-\frac{4}{3}R\frac{5}{3}$	$4.16.\overline{20}.9$	$11.7.\bar{9}$	$d^{\frac{1}{11}}d^{\frac{1}{7}}b^{\frac{1}{9}}$	....	Andreasberg	Sansoni. 1884
ℭ:	$\frac{5}{4}R\frac{9}{5}$	$27\bar{9}4$	$53\bar{4}$	$d^{\frac{1}{5}}d^{\frac{1}{3}}b^{\frac{1}{4}}$	$(\frac{5}{8}P+1)\frac{9}{5}$	Derbyshire	Bournon. 1808
𝔇:	$-\frac{8}{7}R2$	$4.12.\overline{16}.7$	$95\bar{7}$	$d^{\frac{1}{9}}d^{\frac{1}{5}}b^{\frac{1}{7}}$	$(\frac{4}{7}P+1)^2$	Rhisnes	Cesàro. 1889
𝔈:	$-R\frac{7}{3}$	$25\bar{7}3$	$42\bar{3}$	$d^{\frac{1}{4}}d^{\frac{1}{2}}b^{\frac{1}{3}}$	$-(P)\frac{7}{3}$	Hartz	Naumann. 1826
𝔉:	$-\frac{4}{5}R3$	$4.8.\overline{12}.5$	$73\bar{5}$	$d^{\frac{1}{7}}d^{\frac{1}{3}}b^{\frac{1}{5}}$	$(\frac{2}{5}P+1)^3$	Derbyshire	Bournon. 1808
𝔊:	$-\frac{1}{2}R5$	$23\bar{5}2$	$31\bar{2}$	$d^{\frac{1}{3}}d^1b^{\frac{1}{2}}$	$(P-1)^5$	Hartz	Haidinger. 1845
ℌ:	$+\frac{4}{7}R5$	$12.8.\overline{20}.7$	$13.1.\bar{7}$	$d^{\frac{1}{13}}d^1b^{\frac{1}{7}}$	....	Matlock	Hessenberg. 1863
Π:	$+3R\frac{11}{9}$	$10.1.\overline{11}.3$	$41\bar{3}$	$d^{\frac{1}{4}}d^1b^{\frac{1}{3}}$	....	Lake Superior	Palache. 1900
O:	$+2R\frac{5}{3}$	$8.2.\overline{10}.3$	$71\bar{3}$	$d^{\frac{1}{7}}d^1b^{\frac{1}{3}}$	....	New Mexico	Schaller. 1908
				SCALENOHEDRONS OF THE ZONE $[40\bar{4}1.11\bar{2}0]$			
Γ:	$+4R\frac{9}{8}$	$17.1.\overline{18}.4$	$13.\bar{4}.\bar{5}$	$d^{\frac{1}{5}}d^{\frac{1}{4}}b^{\frac{1}{13}}$	....	Lake Superior	Palache. 1900
Δ:	$+4R\frac{7}{6}$	$13.1.\overline{14}.3$	$10.\bar{3}.\bar{4}$	$d^{\frac{1}{4}}d^{\frac{1}{3}}b^{\frac{1}{10}}$	....	Lake Superior	Palache. 1900
Σ:	$+4R\frac{6}{5}$	$22.2.\overline{24}.5$	$17.\bar{5}.\bar{7}$	$d^{\frac{1}{7}}b^{\frac{1}{5}}d^{\frac{1}{17}}$	....	Lake Superior	Palache. 1900

Θ:	$+4R^{\frac{11}{9}}$	$40.4.\overline{44}.9$	$31.\bar{9}.\overline{13}$	$d^{\frac{1}{13}}d^{\frac{1}{9}}b^{\frac{1}{31}}$	....	Lake Superior........	Palache. 1900
Φ:	$+4R\frac{5}{2}$	$9.1.\overline{10}.2$	$72\bar{3}$	$d^{\frac{1}{3}}d^{\frac{1}{2}}b^{\frac{1}{7}}$	....	Lake Superior.........	Palache. 1900
Λ:	$+4R\frac{9}{7}$	$32.4.\overline{36}.7$	$25.\bar{7}.\overline{11}$	$d^{\frac{1}{11}}d^{\frac{1}{7}}b^{\frac{1}{25}}$	....	Lake Superior.........	Palache. 1900
Ξ:	$+4R\frac{4}{3}$	$14.2.\overline{16}.3$	$11.\bar{3}.\bar{5}$	$d^{\frac{1}{5}}d^{\frac{1}{3}}b^{\frac{1}{11}}$	....	Rhisnes.............	Cesàro. 1889
𝔓:	$+4R\frac{3}{2}$	$51\bar{6}1$	$4\bar{1}\bar{2}$	$d^{\frac{1}{2}}d^{1}b^{\frac{1}{4}}$	$(P+2)\frac{3}{2}$	Tharandt............	Breithaupt. 1847
𝔐:	$+4R\frac{5}{3}$	$16.4.\overline{20}.3$	$13.\bar{3}.\bar{7}$	$d^{\frac{1}{7}}d^{\frac{1}{3}}b^{\frac{1}{13}}$	....	Tharandt............	Sachs. 1902
𝔑:	$+4R\frac{7}{4}$	$11.3.\overline{14}.2$	$9\bar{2}\bar{5}$	$d^{\frac{1}{5}}d^{\frac{1}{2}}b^{\frac{1}{9}}$	....	Catskill.............	Whitlock. 1910
ℑ:	$+4R2$	$62\bar{8}1$	$5\bar{1}\bar{3}$	$d^{\frac{1}{3}}d^{1}b^{\frac{1}{5}}$	$(P+2)^{2}$	Derbyshire..........	Bournon. 1808
𝔖:	$+4R^{\frac{11}{4}}$	$15.7.\overline{22}.2$	$13.\bar{2}.\bar{9}$	$d^{\frac{1}{9}}d^{\frac{1}{2}}b^{\frac{1}{13}}$	....	Rhisnes.............	Cesàro. 1889
𝔎:	$+4R3$	$8.4.\overline{12}.1$	$7\bar{1}\bar{5}$	$d^{\frac{1}{5}}d^{1}b^{\frac{1}{7}}$	$(P+2)^{3}$	....	Haüy. 1801
𝔗:	$+4R^{\frac{13}{4}}$	$17.9.\overline{26}.2$	$15.\bar{2}.\overline{11}$	$d^{\frac{1}{11}}d^{\frac{1}{2}}b^{\frac{1}{15}}$	....	Rhisnes.............	Cesàro. 1889
				SCALENOHEDRONS OF THE ZONE	**[01̄12.112̄0]**		
a:	$-\frac{1}{2}R\frac{7}{2}$	$5.9.\overline{14}.8$	$94\bar{5}$	$d^{\frac{1}{5}}d^{\frac{1}{4}}b^{\frac{1}{9}}$	....	Canary Islands........	Hessenberg. 1870
b:	$-\frac{1}{2}R4$	$53\bar{8}4$	$52\bar{3}$	$d^{\frac{1}{3}}d^{\frac{1}{2}}b^{\frac{1}{5}}$	$(P-1)^{4}$	....	Haüy. 1822
c:	$-\frac{1}{2}R7$	$34\bar{7}2$	$41\bar{3}$	$d^{\frac{1}{4}}d^{1}b^{\frac{1}{3}}$	....	Bogoslowsk..........	Kokscharow. 1875
d:	$-\frac{1}{2}R9$	$45\bar{9}2$	$51\bar{4}$	$d^{\frac{1}{5}}d^{1}b^{\frac{1}{4}}$	$(P-1)^{9}$	....	Lévy. 1837
e:	$-\frac{1}{2}R10$	$9.11.\overline{20}.4$	$11.2.\bar{9}$	$d^{\frac{1}{11}}d^{\frac{1}{2}}b^{\frac{1}{9}}$	....	Matlock.............	Hessenberg. 1863
g:	$-\frac{1}{2}R13$	$6.7.\overline{13}.2$	$71\bar{6}$	$d^{\frac{1}{7}}d^{1}b^{\frac{1}{6}}$	$(P-1)^{13}$	Traversella..........	Lévy. 1837
				SCALENOHEDRONS OF THE ZONE	**[0111.112̄0]**		
Λ	$-R\frac{9}{5}$	$27\bar{9}5$	$16.10.\overline{11}$	$d^{\frac{1}{16}}d^{\frac{1}{10}}b^{\frac{1}{11}}$	....	Sardinia.............	Sella. 1856
Σ	$-R^{\frac{11}{6}}$	$5.17.\overline{22}.12$	$13.8.\bar{9}$	$d^{\frac{1}{13}}d^{\frac{1}{8}}b^{\frac{1}{9}}$	....	Rauris..............	Höfer. 1891
Q	$-R2$	$13\bar{4}2$	$74\bar{5}$	$d^{\frac{1}{7}}d^{\frac{1}{4}}b^{\frac{1}{5}}$	....	....	Des Cloizeaux. 1874
F	$-R\frac{8}{3}$	$5.11.\overline{16}.6$	$92\bar{7}$	$d^{\frac{1}{9}}d^{\frac{1}{2}}b^{\frac{1}{7}}$	....	Lake Superior.........	Palache. 1900
Θ	$-R3$	$12\bar{3}1$	$52\bar{4}$	$d^{\frac{1}{5}}d^{\frac{1}{2}}b^{\frac{1}{4}}$	$-(P)^{3}$	Andreasberg..........	Lévy. 1837
Π	$-R^{\frac{11}{3}}$	$4.7.\overline{11}.3$	$62\bar{5}$	$d^{\frac{1}{6}}d^{\frac{1}{2}}b^{\frac{1}{5}}$	....	Couzon..............	Gonnard. 1897
Ω	$-R4$	$35\bar{8}2$	$13.4.\overline{11}$	$d^{\frac{1}{13}}d^{\frac{1}{4}}b^{\frac{1}{11}}$	....	Narsarsuk...........	Flink. 1899
Ψ	$-R5$	$23\bar{5}1$	$82\bar{7}$	$d^{\frac{1}{8}}d^{\frac{1}{2}}b^{\frac{1}{7}}$	$-(P)^{5}$	....	Haüy. 1822
				POSITIVE SCALENOHEDRONS NOT INCLUDED IN		**THE FOREGOING ZONES**	
G	$+\frac{1}{3}R\frac{17}{3}$	$10.7.\overline{17}.9$	$12.1.\overline{10}$	$d^{\frac{1}{12}}d^{1}b^{\frac{1}{10}}$	....	Cumberland.......... Körösmezö...........	Butgenbach. 1897 Moesz. 1897
L	$+\frac{14}{17}R\frac{15}{7}$	$22.8.\overline{30}.37$	$49.23.\overline{41}$	$d^{\frac{1}{49}}d^{\frac{1}{23}}b^{\frac{1}{41}}$	....	Andreasberg..........	Thürling. 1885
𝔴	$+\frac{1}{2}R\frac{11}{3}$	$7.4.\overline{11}.6$	$81\bar{3}$	$d^{\frac{1}{8}}d^{1}b^{\frac{1}{3}}$	....	Lake Superior.........	Palache. 1900
𝔄	$+\frac{1}{2}R13$	$7.6.\overline{13}.2$	$22.1.\overline{17}$	$d^{\frac{1}{22}}d^{1}d^{\frac{1}{17}}$	....	Norberg.............	Johansson. 1892
H	$+\frac{3}{5}R3$	$63\bar{9}5$	$20.1.\bar{7}$	$d^{\frac{1}{20}}d^{1}d^{\frac{1}{7}}$	....	West Paterson........	Whitlock. 1907
𝔟	$+\frac{3}{5}R^{\frac{31}{9}}$	$20.11.\overline{31}.15$	$33.2.\bar{9}$	$d^{\frac{1}{33}}d^{\frac{1}{2}}b^{\frac{1}{9}}$	....	Lake Superior.........	Palache. 1900
N	$+\frac{8}{11}R2$	$12.4.\overline{16}.11$	$13.1.\bar{3}$	$d^{\frac{1}{13}}d^{1}b^{\frac{1}{3}}$	....	Lake Superior.........	Palache. 1900
M	$+\frac{4}{5}R3$	$8.4.\overline{12}.5$	$25.1.\overline{11}$	$d^{\frac{1}{25}}d^{1}b^{\frac{1}{11}}$	....	Lake Superior.........	Palache. 1900
Z	$+\frac{4}{5}R\frac{5}{3}$	$16.4.\overline{20}.5$	$17.1.\bar{3}$	$d^{\frac{1}{17}}d^{1}b^{\frac{1}{3}}$	....	Lake Superior.........	Palache. 1900
𝔞	$+\frac{6}{7}R^{\frac{28}{9}}$	$37.19.\overline{56}.21$	$38.1.\overline{18}$	$d^{\frac{1}{38}}d^{1}b^{\frac{1}{18}}$	....	Lake Superior.........	Palache. 1900

LIST OF FORMS (*continued*)

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	MILLER SYMBOL	LÉVY SYMBOL	MOHS SYMBOL	LOCALITY	AUTHOR AND DATE
I⁝	$+\frac{9}{8}R\frac{25}{9}$	$17.8.\bar{25}.8$	$50.1.\bar{25}$	$d^{\frac{1}{50}}d^{1}b^{\frac{1}{25}}$			Observer not known
$\mathfrak{g}$	$+\frac{6}{5}R\frac{13}{3}$	$16.10.\bar{26}.5$	$47.\bar{1}.\bar{31}$	$d^{\frac{1}{31}}d^{1}b^{\frac{1}{47}}$		Norberg	Johansson. 1892
$\mathfrak{B}$	$+\frac{5}{4}R3$	$10.5.\bar{15}.4$	$29.\bar{1}.\bar{16}$	$d^{\frac{1}{16}}d^{1}b^{\frac{1}{29}}$		Blaton	Sansoni. 1885
T	$+2R3$	$42\bar{6}1$	$11.\bar{1}.\bar{7}$	$d^{\frac{1}{7}}d^{1}b^{\frac{1}{11}}$	$-(P+1)^3$	Hartz, etc.	Haüy. 1801
P	$+2R\frac{10}{3}$	$13.7.\bar{20}.3$	$12.\bar{1}.\bar{8}$	$d^{\frac{1}{8}}d^{1}b^{\frac{1}{12}}$		Lake Superior	Palache. 1900
S	$+\frac{5}{2}R2$	$15.5.\bar{20}.4$	$13.\bar{2}.\bar{7}$	$d^{\frac{1}{7}}d^{\frac{1}{2}}b^{\frac{1}{13}}$	$+(\frac{5}{8}P+2)\frac{2}{5}$	Andreasberg	Haidinger. 1845
$\mathfrak{H}$	$+\frac{5}{2}R\frac{13}{5}$	$9.4.\bar{13}.2$	$8\bar{1}\bar{5}$	$d^{\frac{1}{5}}d^{1}b^{\frac{1}{8}}$		Howes Cave	Whitlock. 1910
$\mathfrak{m}$	$+3R\frac{7}{3}$	$52\bar{7}1$	$13.\bar{2}.\bar{8}$	$d^{\frac{1}{8}}d^{\frac{1}{2}}b^{\frac{1}{13}}$		Budapest	Melczer. 1896
$\mathfrak{l}$⁝	$+3R\frac{9}{4}$	$39.15.\bar{54}.8$	$101.\bar{16}.\bar{61}$	$d^{\frac{1}{61}}d^{\frac{1}{16}}b^{\frac{1}{101}}$		Rossie	Whitlock. 1910
X:	$+3R\frac{23}{9}$	$16.7.\bar{23}.3$	$21.\bar{2}.\bar{11}$	$d^{\frac{1}{11}}d^{\frac{1}{2}}b^{\frac{1}{21}}$		Terlingua	Eakle. 1907
Φ	$+3R\frac{25}{9}$	$17.8.\bar{25}.3$	$15.\bar{2}.\bar{10}$	$d^{\frac{1}{10}}d^{\frac{1}{2}}b^{\frac{1}{15}}$		Rhisnes	Cesàro. 1889
$\mathfrak{n}$	$+\frac{35}{11}R\frac{13}{5}$	$63.28.\bar{91}.11$	$55.\bar{8}.\bar{36}$	$d^{\frac{1}{36}}d^{\frac{1}{8}}b^{\frac{1}{55}}$		Budapest	Melczer. 1896
Δ	$+\frac{49}{13}R\frac{13}{7}$	$70.21.\bar{91}.13$	$58.\bar{13}.\bar{33}$	$d^{\frac{1}{33}}d^{\frac{1}{13}}b^{\frac{1}{58}}$		Andreasberg	Sansoni. 1884
$\mathfrak{o}$	$+\frac{7}{2}R\frac{13}{7}$	$10.3.\bar{13}.2$	$25.\bar{5}.\bar{14}$	$d^{\frac{1}{14}}d^{\frac{1}{5}}b^{\frac{1}{25}}$		Freiberg	Sansoni. 1894
$\mathfrak{C}$	$+\frac{18}{5}R\frac{16}{9}$	$25.7.\bar{32}.5$	$62.\bar{13}.\bar{34}$	$d^{\frac{1}{34}}d^{\frac{1}{13}}b^{\frac{1}{62}}$		Dorfmond	Beykirch. 1901
$\mathfrak{D}$	$+\frac{11}{3}R\frac{19}{11}$	$15.4.\bar{19}.3$	$37.\bar{8}.\bar{30}$	$d^{\frac{1}{30}}d^{\frac{1}{8}}b^{\frac{1}{37}}$		Freiberg	Sansoni. 1894
U	$+5R\frac{7}{5}$	$61\bar{7}1$	$14.\bar{4}.\bar{7}$	$d^{\frac{1}{7}}d^{\frac{1}{4}}b^{\frac{1}{14}}$			Buttgenbach. 1905
			NEGATIVE SCALENOHEDRONS NOT INCLUDED IN THE FOREGOING ZONES				
E[1]	$-\frac{8}{23}R\frac{11}{3}$	$32.56.\bar{88}.69$	$61.31.\bar{25}$	$d^{\frac{1}{61}}d^{\frac{1}{31}}b^{\frac{1}{25}}$		Lake Superior	Palache. 1900
Γ	$-\frac{2}{3}R7$	$6.8.\bar{14}.3$	$23.5.\bar{19}$	$d^{\frac{1}{23}}d^{\frac{1}{5}}b^{\frac{1}{19}}$		Andreasberg	Sansoni. 1884
W	$-\frac{4}{5}R\frac{5}{2}$	$3.7.\bar{10}.5$	$63\bar{4}$	$d^{\frac{1}{6}}d^{\frac{1}{3}}b^{\frac{1}{4}}$	$(\frac{2}{5}P+1)\frac{5}{2}$		Lévy. 1837
$\mathfrak{r}$	$-\frac{5}{6}R\frac{13}{5}$	$4.9.\bar{13}.6$	$23.11.\bar{16}$	$d^{\frac{1}{23}}d^{\frac{1}{11}}b^{\frac{1}{16}}$		Neumark	Schnorr. 1896
$\mathfrak{f}$	$-\frac{6}{7}R\frac{11}{9}$	$2.20.\bar{22}.21$	$15.13.\bar{7}$	$d^{\frac{1}{15}}d^{\frac{1}{13}}b^{\frac{1}{7}}$		Rhisnes	Cesàro. 1889
I·	$-\frac{7}{8}R\frac{55}{21}$	$17.38.\bar{55}.24$	$32.15.\bar{23}$	$d^{\frac{1}{32}}d^{\frac{1}{15}}b^{\frac{1}{23}}$		Lake Superior	Palache. 1900
$\mathfrak{c}$	$-\frac{16}{17}R\frac{3}{2}$	$4.20.\bar{24}.17$	$15.11.\bar{9}$	$d^{\frac{1}{15}}d^{\frac{1}{11}}b^{\frac{1}{9}}$		Utö	Sansoni. 1890
$\mathfrak{d}$	$-\frac{32}{31}R\frac{5}{4}$	$4.36.\bar{40}.31$	$25.21.\bar{15}$	$d^{\frac{1}{25}}d^{\frac{1}{21}}b^{\frac{1}{15}}$		Lake Superior	Palache. 1900
$\mathfrak{f}$	$-\frac{14}{13}R\frac{13}{7}$	$6.20.\bar{26}.13$	$15.9.\bar{11}$	$d^{\frac{1}{15}}d^{\frac{1}{9}}b^{\frac{1}{11}}$		Lake Superior	Palache. 1900
R	$-\frac{8}{7}R\frac{5}{3}$	$8.32.\bar{40}.21$	$23.15.\bar{17}$	$d^{\frac{1}{23}}d^{\frac{1}{15}}b^{\frac{1}{17}}$		Andreasberg	Sansoni. 1884

[1] Palache in a private communication substitutes this form for $-\frac{7}{22}R4 = 21.35.\bar{56}.44$ given in paper cited.

𝔈	$-\frac{8}{7}R\frac{7}{4}$	$3.11.\bar{14}.7$	$85\bar{6}$	$d^{\frac{1}{8}}d^{\frac{1}{5}}b^{\frac{1}{6}}$	....	Andreasberg..........	Thürling. 1885
X	$-\frac{8}{7}R\frac{9}{4}$	$5.13.\bar{18}.7$	$10.5.8$	$d^{\frac{1}{10}}d^{\frac{1}{5}}b^{\frac{1}{8}}$	$(\frac{4}{7}P+1)\frac{9}{4}$	....	Lévy. 1837
A	$-\frac{8}{7}R\frac{5}{2}$	$6.14.\bar{20}.7$	$11.5.9$	$d^{\frac{1}{11}}d^{\frac{1}{5}}b^{\frac{1}{9}}$	....	Lake Superior.........	Palache. 1900
V	$-\frac{6}{5}R\frac{5}{3}$	$2.8.\bar{10}.5$	$17.11.\bar{13}$	$d^{\frac{1}{17}}d^{\frac{1}{11}}b^{\frac{1}{13}}$	....	Andreasberg..........	Sansoni. 1884
C	$-\frac{6}{5}R\frac{7}{6}$	$1.13.\bar{14}.10$	$25.22.\bar{17}$	$d^{\frac{1}{25}}d^{\frac{1}{22}}b^{\frac{1}{17}}$	....	West Paterson........	Whitlock. 1907
K	$-\frac{5}{4}R\frac{6}{5}$	$1.11.\bar{12}.8$	$76\bar{5}$	$d^{\frac{1}{7}}d^{\frac{1}{6}}b^{\frac{1}{5}}$	....	Lake Superior.........	Palache. 1900
D	$-\frac{5}{4}R\frac{11}{5}$	$3.8.\bar{11}.4$	$63\bar{5}$	$d^{\frac{1}{6}}d^{\frac{1}{3}}b^{\frac{1}{5}}$	....	Lake Superior.........	Palache. 1900
I	$-\frac{5}{4}R\frac{12}{5}$	$7.17.\bar{24}.8$	$13.6.\bar{11}$	$d^{\frac{1}{13}}d^{\frac{1}{6}}b^{\frac{1}{11}}$	....	Lake Superior.........	Palache. 1900
t	$-\frac{5}{4}R\frac{8}{5}$	$3.13.\bar{16}.8$	$96\bar{7}$	$d^{\frac{1}{9}}d^{\frac{1}{6}}b^{\frac{1}{7}}$	....	Plainfield, N. J........	Whitlock. 1909
J	$-\frac{4}{3}R\frac{7}{3}$	$8.20.\bar{28}.9$	$15.7.\bar{13}$	$d^{\frac{1}{15}}d^{\frac{1}{7}}b^{\frac{1}{13}}$	....	Guanajuato...........	Pirsson. 1891
i	$-\frac{7}{5}R\frac{16}{7}$	$9.23.\bar{32}.10$	$17.8.\bar{15}$	$d^{\frac{1}{17}}d^{\frac{1}{8}}b^{\frac{1}{15}}$	....	Couzon...............	Gonnard. 1897
Y	$-\frac{20}{13}R\frac{11}{5}$	$12.32.\bar{44}.13$	$23.11.\bar{21}$	$d^{\frac{1}{23}}d^{\frac{1}{11}}b^{\frac{1}{21}}$	....	Bergen Hill..........	vom Rath. 1877
Ξ	$-\frac{31}{20}R\frac{67}{31}$	$18.49.\bar{67}.20$	$35.17.\bar{32}$	$d^{\frac{1}{35}}d^{\frac{1}{17}}b^{\frac{1}{32}}$	....	Elba.................	vom Rath. 1876
𝔉	$-\frac{8}{5}R\frac{10}{7}$	$12.68.\bar{80}.35$	$127.91.\bar{113}$	$d^{\frac{1}{127}}d^{\frac{1}{91}}b^{\frac{1}{113}}$	....	Neumark..............	Schnorr. 1896
𝔩	$-\frac{7}{3}R\frac{13}{7}$	$3.10.\bar{13}.3$	$19.10.\bar{20}$	$d^{\frac{1}{19}}d^{\frac{1}{10}}b^{\frac{1}{20}}$	....	New Mexico..........	Schaller. 1908
𝔊	$-\frac{29}{13}R\frac{32}{29}$	$3.61.\bar{64}.26$	$31.18.\bar{33}$	$d^{\frac{1}{31}}d^{\frac{1}{18}}b^{\frac{1}{33}}$	....	Rhisnes..............	Cesàro. 1889
𝔲	$-\frac{43}{17}R\frac{75}{43}$	$16.59.\bar{75}.17$	$36.20.\bar{39}$	$d^{\frac{1}{36}}d^{\frac{1}{20}}b^{\frac{1}{39}}$	....	Couzon...............	Gonnard. 1897
B	$-\frac{28}{11}R\frac{13}{7}$	$12.40.\bar{52}.11$	$25.13.\bar{27}$	$d^{\frac{1}{25}}d^{\frac{1}{13}}b^{\frac{1}{27}}$	....	Lake Superior.........	Palache. 1900
𝔴	$-3R\frac{9}{7}$	$3.24.\bar{27}.7$	$37.28.\bar{44}$	$d^{\frac{1}{37}}d^{\frac{1}{28}}b^{\frac{1}{44}}$	....	Bamle...............	Morton. 1884
𝔳	$-5R\frac{9}{5}$	$27\bar{9}1$	$42\bar{5}$	$d^{\frac{1}{4}}d^{\frac{1}{2}}b^{\frac{1}{5}}$	....	Budapest............	Melczer. 1896
𝔶	$-\frac{13}{2}R\frac{19}{13}$	$3.16.\bar{19}.2$	$8.5.\bar{11}$	$d^{\frac{1}{8}}d^{\frac{1}{5}}b^{\frac{1}{11}}$	....	Budapest............	Melczer. 1896
𝔷	$-12R\frac{7}{6}$	$1.13.\bar{14}.1$	$16.13.\bar{26}$	$d^{\frac{1}{16}}d^{\frac{1}{13}}b^{\frac{1}{26}}$	....	Freiberg.............	Sansoni. 1894
𝔠	$-5R\frac{6}{5}$	$1.11.\bar{12}.2$	$54\bar{7}$	$d^{\frac{1}{5}}d^{\frac{1}{4}}b^{\frac{1}{7}}$	....	Sommerville..........	Whitlock. 1910
𝔵	$-6R\frac{3}{2}$	$3.15.\bar{18}.2$	$23.14.\bar{31}$	$d^{\frac{1}{23}}d^{\frac{1}{14}}b^{\frac{1}{31}}$	....	Union Springs...... Rondout...........	Whitlock. 1910

LIST OF DOUBTFUL OR UNCERTAIN FORMS

NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	LOCALITY	AUTHOR
$\infty R9$	$54\bar{9}0$	....	Bournon
$\frac{10}{9}P2$	$5.5.\overline{10}.9$		
$+\frac{9}{2}R$	$90\bar{9}2$	....	Zippe
$+\frac{14}{3}R$	$14.0.\overline{14}.3$	....	Des Cloizeaux
$+\frac{17}{4}R$	$17.0.\overline{17}.4$	....	Dana
$+\frac{8}{3}R$	$80\bar{8}3$	Union Springs..............	Penfield and Ford
$+\frac{3}{10}R$	$3.0.\bar{3}.10$	....	Zippe
$-\frac{1}{4}R$	$01\bar{1}4$	....	Hausmann
$-\frac{6}{7}R$	$06\bar{6}7$	Bleiberg....................	Brunlechner
$-\frac{10}{7}R$	$0.10.\overline{10}.7$	Streigau....................	Websky
$-\frac{7}{4}R$	$07\bar{7}4$	Canary Islands.............	Hessenberg
$-6R$	$06\bar{6}1$	Rödefiord, Iceland..........	Hessenberg
$-10R$	$0.10.\overline{10}.1$	Andreasberg................	Sansoni
$-25R$	$0.25.\overline{25}.1$	Rhisnes....................	Cesàro
$-40R$	$0.40.\overline{40}.1$	Rhisnes....................	Cesàro
$-\frac{5}{16}R\frac{9}{5}$	$2.7.\bar{9}.16$	....	Haüy
$+\frac{11}{17}R\frac{15}{11}$	$13.2.\overline{15}.17$		
$+R\frac{15}{11}$	$13.2.\overline{15}.11$		
$+R\frac{21}{5}$	$13.8.\overline{21}.5$	Engis......................	Cesàro
$+R15$	$8.7.\overline{15}.1$	Rhisnes....................	Cesàro
$+R33$	$17.16.\overline{33}.1$	Rhode Island..............	Schaller
$-\frac{7}{5}R\frac{9}{7}$	$9.72.\overline{81}.49$		
$-2R\frac{11}{6}$	$5.17.\overline{22}.6$	Engis......................	Cesàro
$-2R\frac{7}{3}$	$4.10.\overline{14}.3$	Blaton.....................	Sansoni
$-2R\frac{5}{2}$	$3.7.\overline{10}.2$		
$-2R\frac{16}{3}$	$13.19.\overline{32}.3$	Gestrikland.................	Sjögren
$-2R\frac{11}{2}$	$9.13.\overline{22}.2$	Gestrikland.................	Sjögren
$+\frac{1}{5}R\frac{19}{3}$	$11.8.\overline{19}.15$		
$+\frac{1}{4}R23$	$12.11.\overline{23}.4$	....	Des Cloizeaux
$+\frac{1}{3}R\frac{17}{13}$	$10.7.\overline{17}.9$		
$+\frac{3}{7}R\frac{9}{5}$	$21.6.\overline{27}.35$	Port Henry.................	Kemp
$+\frac{2}{5}R5$	$6.4.\overline{10}.5$		
$+\frac{2}{5}R19$	$20.18.\overline{38}.5$	....	Des Cloizeaux
$+\frac{1}{2}R\frac{13}{3}$	$8.5.\overline{13}.6$	....	Zippe
$+\frac{1}{2}R\frac{17}{3}$	$10.7.\overline{17}.3$	Rhisnes....................	Cesàro
$+\frac{11}{20}R\frac{17}{11}$	$14.3.\overline{17}.20$	Rhisnes....................	Cesàro
$+\frac{14}{27}R\frac{11}{3}$	$98.56.\overline{154}.81$	Lake Superior..............	Hessenberg
$+\frac{10}{17}R\frac{35}{9}$	$220.130.\overline{350}.153$	Canary Islands.............	Hessenberg
$+\frac{6}{7}R3$	$12.6.\overline{18}.7$	Bergen Hill.................	vom Rath
$+\frac{16}{17}R\frac{5}{2}$	$28.12.\overline{40}.17$	Blaton.....................	Sansoni
$+\frac{8}{7}R\frac{13}{3}$	$64.40.\overline{104}.21$	Rhisnes....................	Cesàro
$+\frac{13}{12}R\frac{41}{13}$	$27.14.\overline{41}.12$	Rhisnes....................	Cesàro
$+\frac{13}{11}R\frac{9}{7}$	$104.13.\overline{117}.187$	Port Henry.................	Kemp

LIST OF DOUBTFUL OR UNCERTAIN FORMS (*continued*)

NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	LOCALITY	AUTHOR
$+\frac{31}{25}R\frac{99}{31}$	$65.34.\overline{99}.25$	Rhisnes	Cesàro
$+\frac{14}{11}R\frac{27}{7}$	$34.20.\overline{54}.11$	Rhisnes	Cesàro
$+\frac{4}{3}R\frac{11}{3}$	$28.16.\overline{44}.9$	Rhisnes	Cesàro
$+\frac{7}{5}R\frac{53}{21}$	$37.16.\overline{53}.15$	Rhisnes	Cesàro
$+\frac{10}{7}R\frac{17}{5}$	$22.12.\overline{34}.7$	Rhisnes	Cesàro
$+\frac{13}{7}R\frac{45}{13}$	$29.16.\overline{45}.7$	Rhisnes	Cesàro
$+\frac{8}{5}R3$	$16.8.\overline{24}.5$	Rhisnes	Cesàro
$+2R\frac{11}{4}$	$15.7.\overline{22}.4$	Rossie	Hessenberg
$+\frac{17}{8}R\frac{37}{17}$	$27.10.\overline{37}.8$	Rhisnes	Cesàro
$+\frac{8}{3}R2$	$12.4.\overline{16}.3$		Des Cloizeaux
$+\frac{23}{8}R\frac{51}{23}$	$37.14.\overline{51}.8$	Rhisnes	Cesàro
$+\frac{15}{4}R\frac{5}{3}$	$20.5.\overline{25}.4$	Blaton	Sansoni
$+\frac{13}{4}R\frac{25}{13}$	$19.6.\overline{25}.4$	Rhisnes	Cesàro
$+\frac{29}{8}R\frac{55}{29}$	$42.13.\overline{58}.8$	Bleiberg	Irby substitutes
$+\frac{17}{2}R\frac{23}{17}$	$20.3.\overline{23}.2$		Zippe
$+10R\frac{17}{15}$	$32.2.\overline{34}.3$		Zippe
$+10R\frac{9}{5}$	$14.4.\overline{18}.1$		Des Cloizeaux
$+12R\frac{11}{9}$	$40.4.\overline{44}.3$	Rhisnes	Cesàro
$+28R\frac{19}{14}$	$33.5.\overline{38}:1$	Rhisnes	Cesàro
$-\frac{1}{5}R13$	$6.7.\overline{13}.5$		
$-\frac{1}{4}R15$	$7.8.\overline{15}.4$	Andreasberg	Sansoni
$-\frac{1}{4}R\frac{71}{3}$	$34.37.\overline{71}.12$		Zippe
$-\frac{1}{2}R\frac{7}{3}$	$25\bar{7}6$		Zippe
$-\frac{1}{2}R\frac{13}{3}$	$5.8.\overline{13}.6$		Zippe
$-\frac{1}{2}R11$	$5.6.\overline{11}.2$		Des Cloizeaux
$-\frac{22}{41}R\frac{40}{11}$	$29.51.\overline{80}.41$	Lake Superior	Irby
$-\frac{5}{9}R\frac{17}{5}$	$6.11.\overline{17}.9$	Lake Superior	Irby
$-\frac{4}{7}R\frac{10}{3}$	$14.26.\overline{40}.21$	Lake Superior	Irby
$-\frac{3}{5}R3$	$36\bar{9}5$	Lake Superior	Hessenberg
$-\frac{8}{13}R3$	$8.16.\overline{24}.3$	Lake Superior	Irby
$-\frac{5}{7}R\frac{17}{15}$	$6.11.\overline{17}.7$	Blaton	Sansoni
$-\frac{5}{7}R\frac{11}{5}$	$3.8.\overline{11}.7$	Rhisnes	Cesàro
$-\frac{4}{5}R2$	$26\bar{8}5$	Andreasberg	Sansoni
$-\frac{5}{6}R\frac{9}{5}$	$27\bar{9}6$	Andreasberg	Sansoni
$-\frac{7}{8}R\frac{15}{7}$	$4.11.\overline{15}.8$		
$-\frac{10}{11}R\frac{8}{5}$	$3.13.\overline{16}.11$	Lake Superior	Irby
$-\frac{10}{11}R\frac{12}{5}$	$7.17.\overline{24}.11$	Utö	Sansoni
$-\frac{16}{17}R\frac{5}{2}$	$12.28.\overline{40}.17$	Blaton	Sansoni
$-R\frac{13}{3}$	$5.8.\overline{13}.3$		
$-R7$	$34\bar{7}1$	Andreasberg	Thürling
$-\frac{27}{26}R\frac{13}{9}$	$6.33.\overline{39}.26$	Andreasberg	Sansoni
$-\frac{23}{22}R\frac{33}{23}$	$5.28.\overline{33}.22$	Andreasberg	Cesàro
$-\frac{17}{15}R\frac{37}{17}$	$10.27.\overline{37}.15$	Lake Superior	Hessenberg
$-\frac{8}{7}R\frac{9}{4}$	$5.13.\overline{18}.7$		Lévy

LIST OF DOUBTFUL OR UNCERTAIN FORMS *(continued)*

NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	LOCALITY	AUTHOR
$-\frac{7}{6}R\frac{13}{7}$	$3.10.\bar{13}.6$	Andreasberg	Sansoni
$-\frac{7}{6}R\frac{20}{7}$	$13.27.\bar{40}.12$	Andreasberg	Sansoni
$-\frac{13}{11}R\frac{37}{13}$	$12.25.\bar{37}.11$	Andreasberg	Cesàro
$-\frac{6}{5}R\frac{13}{3}$	$10.16.\bar{26}.5$	Andreasberg	Sansoni
$-\frac{28}{23}R\frac{13}{7}$	$12.40.\bar{52}.23$	Blaton	Sansoni
$-\frac{5}{4}R\frac{21}{5}$	$8.13.\bar{21}.4$	Blaton	Cesàro
$-\frac{19}{15}R\frac{91}{57}$	$17.74.\bar{91}.45$		vom Rath
$-\frac{4}{3}R3$	$4.8.\bar{12}.3$	Rhisnes	Cesàro
$-\frac{7}{5}R\frac{3}{2}$	$7.35.\bar{42}.20$	Bergen Hill	Dana
$-\frac{17}{12}R\frac{73}{31}$	$11.62.\bar{73}.36$		vom Rath
$-\frac{3}{2}R\frac{34}{27}$	$7.61.\bar{68}.36$		Zippe
$-\frac{3}{2}R\frac{7}{3}$	$25\bar{7}2$	Cumberland	Bournon
$-\frac{8}{5}R\frac{9}{4}$	$5.13.\bar{18}.5$		Des Cloizeaux
$-\frac{8}{5}R3$	$8.16.\bar{24}.5$	Rhisnes	Cesàro
$-\frac{7}{4}R\frac{25}{21}$	$2.23.\bar{25}.12$		Des Cloizeaux
$-\frac{16}{7}R\frac{3}{2}$	$4.20.\bar{24}.7$	England	Schaller
$-\frac{19}{9}R\frac{89}{57}$	$16.73.\bar{89}.27$	Lancashire	vom Rath
$-\frac{25}{9}R\frac{27}{25}$	$1.26.\bar{27}.9$	Rhisnes	Cesàro
$-3R\frac{13}{9}$	$2.11.\bar{13}.6$	Rhisnes	Cesàro
$-\frac{38}{7}R\frac{25}{19}$	$6.44.\bar{50}.7$		Des Cloizeaux
$-6R\frac{5}{3}$	$2.8.\bar{10}.1$		Des Cloizeaux
$-8R5$	$16.24.\bar{40}.1$	Andreasberg	Hessenberg
$-11R\frac{6}{5}$	$1.11.\bar{12}.1$	Andreasberg	Sansoni
$-14R\frac{9}{7}$	$2.16.\bar{18}.1$	Rhode Island	Schaller
$-15R\frac{17}{15}$	$1.16.\bar{17}.1$	Andreasberg	Sansoni
$-29R\frac{31}{29}$	$1.30.\bar{31}.1$	Alston Moor	Des Cloizeaux
$-66R\frac{35}{33}$	$2.68.\bar{70}.1$	Alston Moor	Cesàro
$-161R\frac{25}{23}$	$7.168.\bar{175}.1$	Alston Moor	Zippe

Twinning. Composite crystals, in which two or more parts are united in reversed position according to definite crystallographic laws of orientation are known as twin crystals and the laws which govern their formation are known as twinning laws. The species calcite is characterized by twin crystals formed in accordance with four laws distinguished by the position of the twinning plane, that is to say the plane of juncture between the composite elements of the twin crystal. Taking these four twinning laws in the order of their frequency they may be briefly stated as follows:

1 Twinning parallel to the basal plane is very common, the vertical axis of both elements lie in the same line. Figure 21 shows the scalenohedron K: (21$\bar{3}$1) twinned according to this law.

2 Twinning parallel to the negative rhombohedron δ. (01$\bar{1}$2) is common; the vertical or polar axes of the two elements of the composite crystal form an angle of 127° 29½′. Figure 22 shows the positive scalenohedron K: (21$\bar{3}$1) twinned according to this law.

3 Twinning parallel to the positive rhombohedron p. (10$\bar{1}$1) is uncommon; the vertical or polar axes of the two elements of the composite crystal form an angle of 90° 46′. Figure 23 shows the positive scalenohedron K: (21$\bar{3}$1) twinned according to this law.

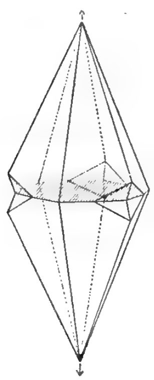


Fig. 21

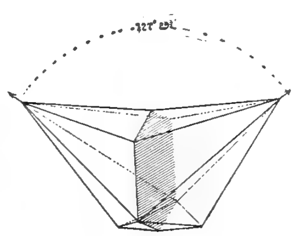


Fig. 22

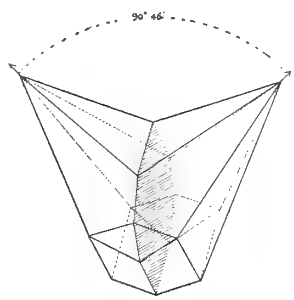


Fig. 23

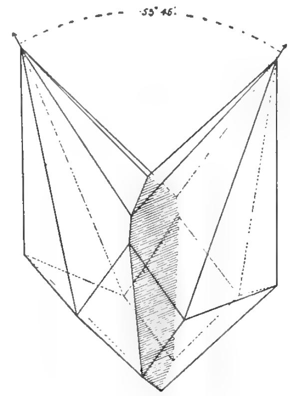


Fig. 24

4 Twinning parallel to the negative rhombohedron φ. (02$\bar{2}$1) is rare; the vertical or polar axes of the two elements of the composite crystal form an angle of 53° 46′. Figure 24 shows the positive scalenohedron K: (21$\bar{3}$1) twinned according to this law.

The position of the twinning plane in the first, second and fourth of the above cases is shown in plate 19, figure 1.

Formulas for calculating angles. For the identification of crystal forms of calcite it is necessary to compare the interfacial or the coordinate angles of the observed form, as measured by some form of goniometer, with the corresponding theoretical angles as calculated from the assumed indexes of the form. All types of reflection goniometers read the normal angles

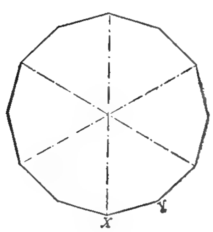
which are the supplements of the true interfacial angles between the faces measured. The general formula for the normal angle between any two faces $P = (h\ k\ \bar{i}\ l)$ and $P' = (h'\ k'\ \bar{i}'\ l')$ expressed in terms of the Bravais-Miller indexes is:

$$\text{Cos } P\,P' = \frac{3\,l\,l' + 2\,c^2\,(h\,k' + k\,h' + 2\,h\,h' + 2\,k\,k')}{\sqrt{[3l^2 + 4c^2\,(h^2 + k^2 + hk)]\ [3l'^2 + 4c^2\,(h'^2 + k'^2 + h'\,k')]}}$$

in which $c = 0.8543$

This general formula becomes much simplified for the special cases involving the angles between faces of the same form or between the faces of any given form and those of the basal pinacoid, prism of the first and second order and unit rhombohedron. These modified formulas are as follows:

1 Dihexagonal prisms $(h\ k\ i\ o)$



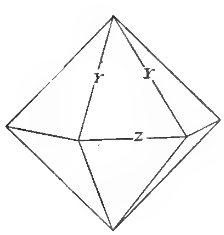
$$\text{Cos X (axial)} = \frac{h^2 + k^2 + 4hk}{2(h^2 + k^2 + hk)}$$

$$\text{Cos Y (diagonal)} = \frac{2h^2 + 2hk - k^2}{2(h^2 + k^2 + hk)}$$

$$\text{Cos } (11\bar{2}0:\ h\ \bar{k}\ i\ o) = \frac{3(h + k)}{\sqrt{12(h^2 + k^2 + hk)}}$$

$$\text{Cos } (10\bar{1}1:h\ k\ \bar{i}\ o) = \frac{2c^2(2h + k)}{\sqrt{[4c^2(h^2 + k^2 + hk)] \times 5.9193}}$$

2 Pyramids of the second order $(h.\ h.\ \overline{2h}.\ l)$

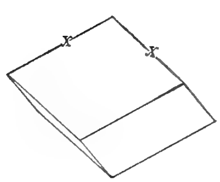


$$\text{Cos Y (terminal)} = \frac{l^2 + 2c^2h^2}{l^2 + 4c^2h^2}$$

$$\text{Cos Z (basal)} = \frac{4c^2h^2 - l^2}{l^2 + 4c^2h^2}$$

$$\text{Cos } (10\bar{1}1:\ h.h.\overline{2}h.l) = \frac{3(l + 2hc^2)}{\sqrt{3(l^2 + 4c^2h^2) \times 5.9193}}$$

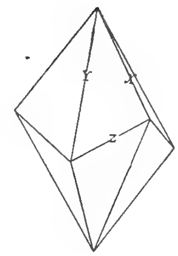
3 Rhombohedrons $(h\ o\ \bar{h}\ l)$



$$\text{Cos X (terminal)} = \frac{3l^2 - 2h^2c^2}{3l^2 + 4h^2c^2}$$

$$\text{Tan } (0001:h\ o\ \bar{h}\ l) = \frac{h}{l} \times .986447$$

4 Scalenohedrons $(h\ k\ i\ \bar{l})$



$$\text{Cos X, } (h\ k\ \bar{i}\ l : \bar{h}\ i\ \bar{k}\ l) = \frac{3l^2 + 2c^2(2k^2 + 2hk - h^2)}{3l^2 + 4c^2(h^2 + k^2 + hk)}$$

$$\text{Cos Y, } (h\ k\ \bar{i}\ l : i\ \bar{k}\ \bar{h}\ l) = \frac{3l^2 + 2c^2(2h^2 + 2hk - k^2)}{3l^2 + 4c^2(h^2 + k^2 + hk)}$$

$$\text{Cos Z, } (h\ k\ \bar{i}\ l : k\ h\ \bar{i}\ \bar{l}) = \frac{2c^2(h^2 + k^2 + 4hk) - 3l^2}{3l^2 + 4c^2(h^2 + k^2 + hk)}$$

$$\text{Cos } (h\ k\ \bar{i}\ l : 10\bar{1}1) = \frac{3l + 2c^2(k + 2h)}{\sqrt{[3l^2 + 4c^2(h^2 + k^2 + hk)] \times 5.9193}}$$

$$\text{Cos } (h\ k\ i\ l : 10\bar{1}0) = \frac{c\ (k + 2h)}{\sqrt{3l^2 + 4c^2\ (h^2 + k^2 + hk)}}$$

$$\text{Cos } (h\ k\ i\ l : 0001) = \frac{l\sqrt{3}}{\sqrt{3l^2 + 4c^2\ (h^2 + k^2 + hk)}}$$

The relation between X, Y and Z is expressed in the following equation:

$$\sin \tfrac{1}{2} X + \sin \tfrac{1}{2} Y = \cos \tfrac{1}{2} Z$$

To find the Naumann symbol of any scalenohedron from measurements of any two of the angles X, Y and Z

$$n = \frac{\cos \frac{1}{2}\ (180 - X) + \cos \frac{1}{2}\ (180 - Y)}{\cos \frac{1}{2}\ (180 - X) - \cos \frac{1}{2}\ (180 - Y)}$$

$$n = \frac{\sin \frac{1}{2}\ (180 - Z)}{2\ \cos \frac{1}{2}\ (180 - X) - \sin \frac{1}{2}\ (180 - Z)}$$

$$n = \frac{\sin \frac{1}{2}\ (180 - Z)}{\sin \frac{1}{2}\ (180 - Z) - 2\ \cos \frac{1}{2}\ (180 - Y)}$$

$$\frac{\tan \frac{1}{2}\ (180 - Z)}{n\sqrt{3}} = \cos \xi \qquad m = \cot \xi + 2.0274$$

For the calculation of the coordinate angles employed in measurement with the two circle goniometer, as well as in the construction of the various spherical projections, the following formulas, adopted from Moses and Rogers[1] give the values of φ and ρ

[1] Moses, A. J. & Rogers, A. F. Formulae and Graphic Methods for Determining Crystals in Terms of Coordinate Angles and Miller Indices. Sch. of Mines Quar. 1902. 29:1.

1 Dihexagonal prisms $(h\, k\, \bar{i}\, o)$

$$\tan \varphi = 1.732 \frac{i - h}{i + h} \qquad \rho = 90°$$

2 Pyramids of the second order $(h.\, h.\, \overline{2h}.\, 1)$

$$\varphi = 30° \qquad \tan \rho = 2 \frac{h}{1} c$$

3 Rhombohedrons $(h\, o\, h\, 1)$

$$\varphi = 0° \qquad \tan \rho = 1.1547 \frac{h}{1} c$$

4 Scalenohedrons $(k\, k\, \bar{i}\, 1)$

$$\tan \varphi = 1.732 \frac{i - h}{i + h} \qquad \tan \rho = \frac{i}{1} \cdot \frac{c}{\cos (30 - \varphi)}$$

In many instances it will be found that the above formulas do not lend themselves to logarithmic solution. For such cases the following multiplication table of constants will be found useful.

	c	2c	$2c^2$	$4c^2$	$\sqrt{3}$	$1.1547 \times c$	2.0274	5.9193
1	.8543	1.7086	1.4597	2.9193	1.7321	.9865	2.0274	5.9193
2	1.7086	3.4172	2.9193	5.8386	3.4641	1.9730	4.0548	11.8386
3	2.5629	5.1258	4.3790	8.7580	5.1962	2.9594	6.0822	17.7579
4	3.4172	6.8344	5.8386	11.6773	6.9282	3.9459	8.1096	23.6772
5	4.2715	8.5430	7.2983	14.5966	8.6603	4.9323	10.1370	29.5965
6	5.1258	10.2516	8.7580	17.5159	10.3923	5.9188	12.1644	35.5158
7	5.9801	11.9602	10.2176	20.4352	12.1244	6.9053	14.1918	41.4351
8	6.8344	13.6688	11.6773	23.3546	13.8564	7.8917	16.2192	47.3544
9	7.6887	15.3774	13.1369	26.2739	15.5885	8.8781	18.2466	53.2737
log.	$\bar{1}$.93161	.23264	.16426	.46528	.23856	$\bar{1}$.99408	.30694	.77227

METHODS OF REPRESENTATION

The various methods employed for presenting to the eye the relations between the faces developed on a given crystal may be included under three heads:

1 *Spherical projections*, which are purely diagrammatic and which represent by means of groups of points projected upon a plane the relative

position of the crystal faces in space without regard to their relative development or crystal habit.

2 *Linear projections*, which are, in a measure, diagramatic and which show by a system of intersecting lines, the intersection of the crystal faces with some assumed plane or with one another as projected on some assumed plane. The latter type of projection shows the relative development of the forms present and presents to the eye an idealized picture of the crystal combination.

3 *Models*, which, constructed of paper, cardboard or of some easily workable material, present in three dimensions the idealized representation of the forms in relative development.

SPHERICAL PROJECTIONS

The method of spherical projection was introduced by F. E. Neumann[1] and later adopted by Miller.

Stereographic projection. To develop the principles of this method assume the crystal of calcite shown in figure 25 to be placed with the center of its crystallographic axes coincident with the center of a circumscribed sphere of any convenient radius. From the common center assume radii *normal* to the faces of the upper half of the crystal. The points where these normals intersect the surface of the sphere are known as the poles of the corresponding faces and accurately represent the relative position of the crystallographic planes, inasmuch as they provide a means of measuring the angles between the normals, which is the supplement of the interfacial angles, between any two planes. To

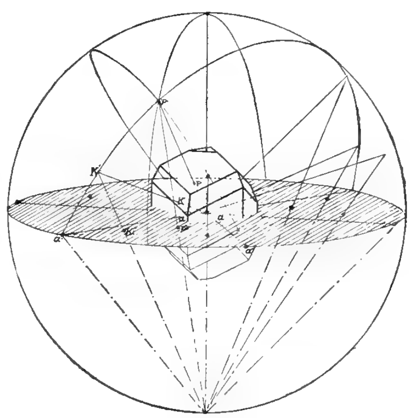


Fig. 25

reduce the above system of poles distributed over a spherical surface to a flat projection assume for the plane of projection the plane of the hori-

[1] Neumann, F. E. Beiträge zur Kristallonomie. Berlin 1823.

zontal axes which is indicated in figure 25 by the shaded portion. This plane intersects the surface of the sphere in a horizontal circle known as the fundamental circle (German, *grundkreis*) which passes through the poles of all prismatic planes. Connect the poles by a system of radiating lines with the lower pole of the vertical axis; the points at which this system of lines intersects the plane of projection is shown in figure 26 which is known as a stereographic projection of the planes of the calcite crystal shown in figure 25. It is evident from figures 25 and 26:

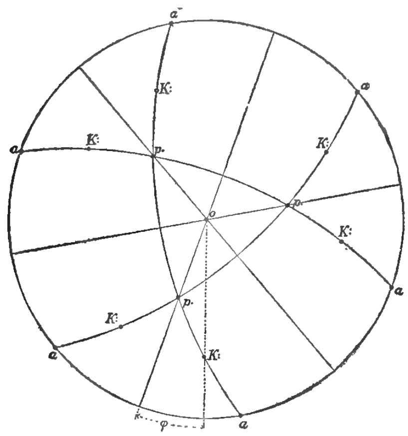


Fig. 26

1 That the basal pinacoid will be projected at the center of the fundamental circle.

2 That the poles of all planes lying in the same zone will fall on the same great circle of the sphere.

3 That the projections of the poles of planes lying in zones which include the basal pinacoid will lie on radii of the fundamental circle. This applies to rhombohedrons and pyramids of the second order.

In order to determine the relative positions of the pole of any plane such as K: in spherical projections [fig. 26] it is sufficient to record the angular distance from a fixed point on the fundamental circle to the vertical great circle through the pole, and the angular distance measured on this great circle from the vertical pole (for hexagonal forms that of the basal pinacoid) to the pole of the given form. The first of these angles is known as φ and the second as ρ; they correspond respectively to geographic longitude and latitude, the fundamental circle corresponding to the geographic equator.

The stereographic projection greatly facilitates the recognition of zonal relations and provides a graphic method of solution for many of the crystallographic problems.[1]

[1] The solution of problems in stereographic projection have been much simplified by the introduction of a set of stereographic protractors devised by S. L. Penfield. Am. Jour. Sci. 1901. 2:1 and 115.

Gnomonic projection. The gnomonic projection, which has come into considerable use in recent years, usually assumes the plane of projection tangent to the circumscribed sphere at the upper vertical pole, figure 27. The projection of the pole of any face is situated at the intersection of the extended normal of the face with this tangent plane. All zones are projected in gnomonic projection as straight lines. The poles of the prismatic zone do not appear in projection since their normals are parallel to the gnomonic projection plane. Plate 1 [*see* pocket] is a gnomonic projection of the established forms of calcite constructed on the basis of a sphere of 7 centimeters radius.

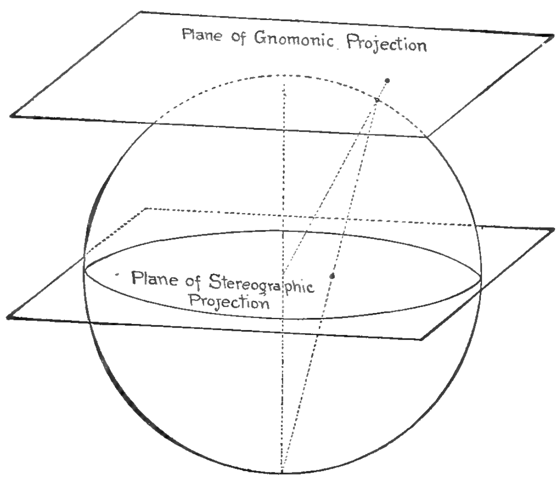


Fig. 27

LINEAR PROJECTIONS

For purposes of description and illustration it is necessary to represent the crystallographic combination by a drawing of its intersecting edges. This is accomplished by viewing the crystal in various positions the point of vision in every case being assumed at an infinite distance. Two such parallel projections are in general employed for this purpose. They assume:

1 The plane of projection perpendicular to the vertical axis. This is known as the orthographic projection.

2 The vertical plane of projection as revolved to the right with respect to the horizontal axis II [fig. 15] and slightly inclined toward the upper prolongation of the vertical axis. This is known as the clinographic projection.

The orthographic projection which is essentially a plan of the crystal observed from above, is closely related to the stereographic spherical projection and can be readily constructed from it.[1]

[1] Story-Maskelyne, N. Treatise on the Morphology of Crystals. Oxford 1895. p. 476.

The clinographic projection represents the crystal in parallel perspective and is specially valuable as presenting the aspect which shows it to the best advantage.

Both orthographic and clinographic projections are used throughout this work, the orthographic projection, where used, being represented as revolved horizontally to correspond with the corresponding clinographic projection, as in figures 3, 4 and 5.

MODELS

Models of the simple forms of calcite may be constructed from paper or cardboard by the use of the diagram given in plate 2. This diagram is based upon the triangle of the horizontal diagonals of figure 7.

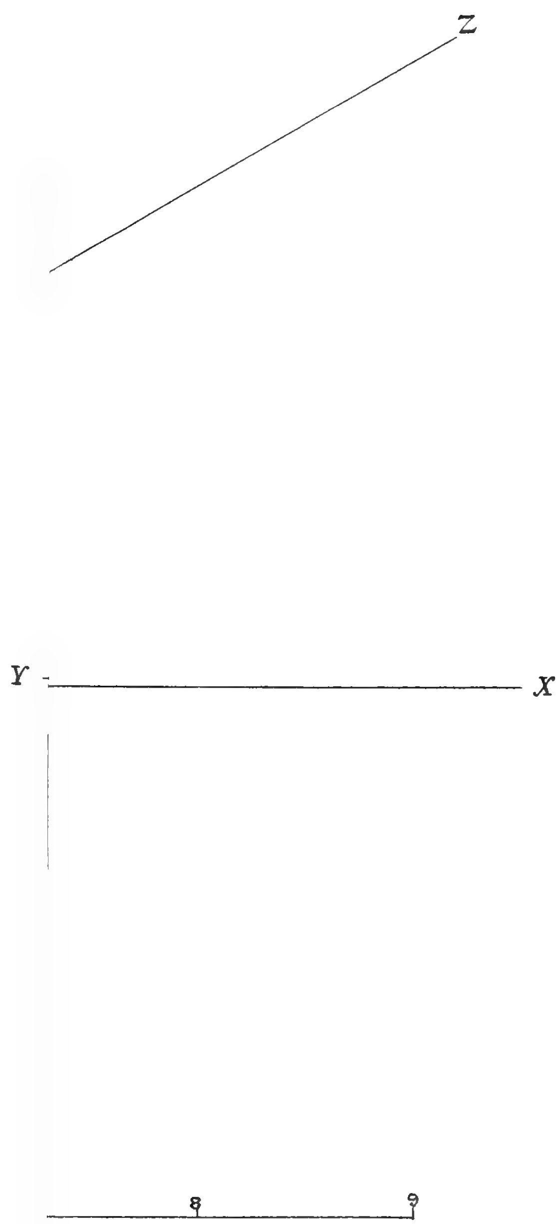
To construct the face rhomb of any rhombohedron measure with a pair of dividers the distance from the point a to the point on the line C corresponding to the coefficient of R in the Naumann symbol, and lay off the distance from a on the line Z. Connect the point thus obtained with points bb′ and complete the parallelogram which will be the desired rhomb.

To construct the triangular face of a second order pyramid, multiply the coefficient m of the Naumann symbol mP2 by $\frac{3}{2}$, measure the distance from the point d to the corresponding number on the line C, lay off this distance on the line Y, and connect the point obtained with the points f f′; the resulting isosceles triangle will be the face of the desired pyramid.

To construct the scalene triangle of a scalenohedron, the problem resolves itself into finding the lengths of the three edges of the triangle which may then be plotted in the ordinary way by means of arcs of circles. The edge Z which is that of the rhombohedron of the middle edges is obtained by the process described for rhombohedrons using the coefficient m in the Naumann symbol mRn. The two polar edges are obtained in the following way: Lay off to the left of point O on the line Y a distance corresponding to m measured on C′ and from the point thus obtained lay off in the directions X and Y a distance corresponding to the product of m and n in the symbol mRn measured on the base line at the bottom of

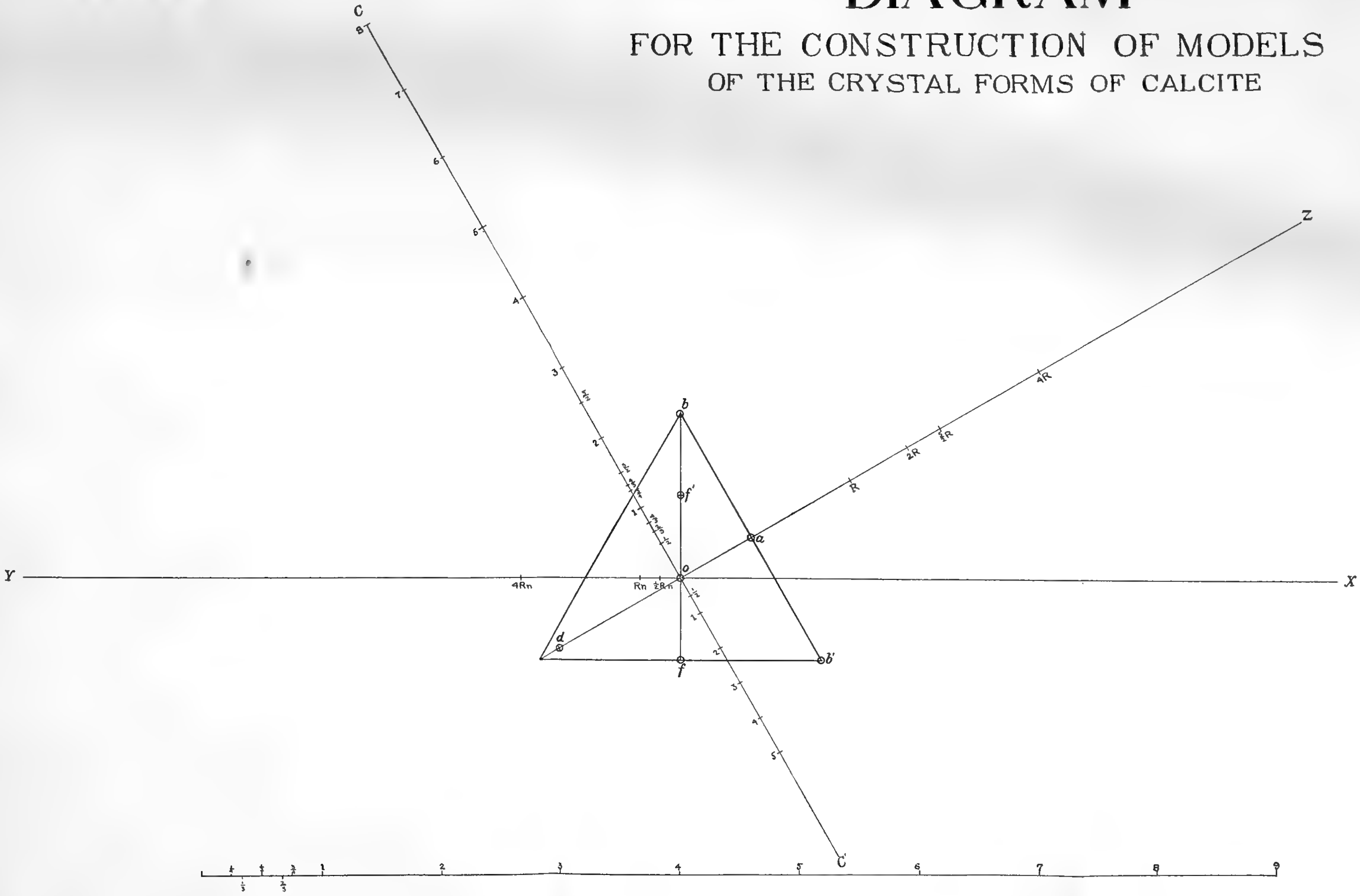
M

N OF MODELS
OF CALCITE



H. P. W. del.

DIAGRAM
FOR THE CONSTRUCTION OF MODELS
OF THE CRYSTAL FORMS OF CALCITE



H. P. W. del.

the plate, connect the two points thus obtained with point b and the resulting lines will be the edges X and Y required.

Several of the important points are indicated on the plate which is of simple construction and can be easily duplicated since the sides of the triangle are twice the length of the horizontal axis, the base line scale proportional to the vertical axis, the scale C proportional to $\frac{2}{3}$ and the scale C′ proportional to $\frac{1}{3}$ the vertical axis.

A cardboard model of the crystal habit of any combination can readily be reproduced in plaster of paris or paraffine, furnishing blocks upon which the modifications may be cut with a knife blade, file or emery paper scraper.

DESCRIPTIONS OF OCCURRENCES

ROSSIE, ST LAWRENCE CO.

Plates 3-5

The calcite crystals from Rossie have long been known to mineral collectors, and handsome specimens of the large and perfect combinations from this locality are to be found in every important mineral collection. This locality is situated 2 miles southwest of the village of Rossie where between the years 1835 and 1840 several openings were made in a vein of galena which were after this period abandoned. During the time of operation, however, a mass of material of remarkable mineralogic interest was brought to light including specimens of galena, pyrite, calcite and celestite of special quality, as well as associated fluorite, chalcopyrite, anglesite, hematite and rare cerussite. Beck mentions the calcite as occurring in water-filled cavities of the mine, associated with crystallized galena, pyrite and chalcopyrite. To this association should be added fluorite and marcasite which latter mineral was noted by the writer on a fine specimen in the Bement collection.

The material is of exceptional quality, the smaller crystals which afforded the material for goniometer study being remarkably free from distortion and conforming closely to the idealized representations given in the figures.

Type I [pl. 3, fig. 1, 2]. The crystals included under this type repre-

sent the simplest combinations of this occurrence. They are in general considerably larger than individuals of the succeeding types. A number of crystals of this habit which were collected by the late Professor Emmons are in the collection of the New York State Museum and measure 10 centimeters in diameter. Many of these are faintly lilac in color, resembling in this respect the recent find of calcite at Sterlingbush, Lewis co. On two crystals from the collection of the American Museum of Natural History,[1] the scalenohedral faces $(62\bar{8}1)$ were covered with minute crystallizations of chalcopyrite and marcasite.

This type is unquestionably identical with that first described by Zippe,[2] figure 1, and later figured by Hessenberg.[3] The positive rhombohedron q. $(70\bar{7}1)$ noted in this paper was not observed by these writers while, on the other hand, a flat scalenohedron of the zone $[10\bar{1}1.11\bar{2}0]$, w: $(31\bar{4}5)$ given by Zippe was not found by the writer on the material available, although this latter form is well defined on the crystals of type IV.

Pinacoid. The planes of the basal pinacoid o (0001) are in many instances conspicuously developed, the faces being universally roughened by etch pits.

Prisms. The prism a $(11\bar{2}0)$ is present as a series of very narrow but fairly brilliant planes beveling the basal edges of $\mathfrak{z}$: $(62\bar{8}1)$.

Rhombohedrons. The unit rhombohedron p. $(10\bar{1}1)$ is present as a dominant form throughout the four types to be described under the occurrence. The planes are somewhat dull but smooth and yield fair reflections. The rhombohedron m. $(40\bar{4}1)$ is present in all the crystals measured, as a series of brilliant triangular planes yielding fine reflections. A narrow rhombohedron q. $(70\bar{7}1)$ beveling the obtuse polar edges of the scalenohedron $\mathfrak{z}$: $(62\bar{8}1)$ is present on one of the crystals measured. A small

[1] The writer is indebted to Prof. L. P. Gratacap for the privilege of studying these interesting specimens.

[2] Zippe, F. X. M. Denkschr. der Akad. d. Wiss. Wien. Math.— Naturwiss. 1852. Class III, fig. 10.

[3] Hessenberg, F. Min. Notizen III. 1860. pl. 2, fig. 23.

development of the negative rhombohedron $\varphi.(02\bar{2}1)$ was noted several times in the measurement of this zone.

Scalenohedrons. The positive scalenohedron $\mathfrak{J}:(62\bar{8}1)$ which with the rhombohedrons p. and m. is characteristic of the occurrence is here developed to the extent of a dominant form. On the whole crystals of this type are characterized by a rhombohedral-scalenohedral habit and are closely allied crystallographically to types III and IV. Figure 2 represents a characteristic combination of this type.

Type II [pl. 3, fig. 3]. The crystals referable to this type were obtained from a specimen loaned for study through the courtesy of Mr D. H. Newland, Assistant State Geologist. These vary in size from 50 millimeters to 5 millimeters in diameter and occur closely associated with light green fluorite of octahedral habit and small isolated crystals of chalcopyrite. The type was measured from three of the smallest crystals which were notably brighter and sharper than those of larger size. The crystals are notably more rhombohedral in habit than those of type I, the modifying planes for the most part beveling the edges of the primary rhombohedron. The figure[1] given by J. D. Dana in his review of Beck's *Mineralogy of New York* strongly suggests this type. The basal and prismatic planes of type I are entirely absent from crystals of this habit.

Rhombohedrons. Besides the rhombohedrons p. $(10\bar{1}1)$ and m. $(40\bar{4}1)$ common to the occurrence, the negative rhombohedron $(02\bar{2}1)$ noted as occasionally present on type I is here sharply developed as a characteristic form giving fair reflections from brilliant, well defined planes.

Scalenohedrons. Two positive scalenohedrons f: $(7.2.\bar{9}.11)$ and K: $(21\bar{3}1)$ in the zone $[01\bar{1}2.10\bar{1}1]$ appear as well defined forms beveling the polar and basal edges of p. Of these f: $(7.2.\bar{9}.11)$ approaches closely in angles to the scalenohedron w: $(31\bar{4}5)$ of the same zone present on crystals of type IV. It is quite evident, however, from a consideration of the angles observed in relation to these two forms that they are distinct and are both present as cited.

[1] Dana, J.D. Am. Jour. Sci. 1844. 44:33, fig. 1.

The common scalenohedron K: $(21\bar{3}1)$ here present as a dominant form, clearly defines the type as crystallographically distinct. The scalenohedron $\mathfrak{J}$: $(62\bar{8}1)$ characteristic of the occurrence is here represented by extremely small planes, a fact which seems to additionally define the combination of this type from those of types I and III which latter appear to bear some crystallographic relation to one another.

Two negative scalenohedrons in the zone $[10\bar{1}1.02\bar{2}1]$ are present. Of these the new form $\mathfrak{s}$: $(4.6.\overline{10}.1)$ is developed as a series of large and brilliant planes giving fine reflection and furnishing a series of measured angles which agree closely with the calculated values for this form. The scalenohedron $\mathfrak{q}$: $(24\bar{6}1)$ which is quite common for calcite is here developed as a series of narrow planes beveling the edges between $\mathfrak{s}$: and φ.. In habit the crystals of this type are rhombohedral, the relative development of the occurring forms being shown in figure 3.

Type III [pl. 3, figs. 4, 5]. Crystals of type III were obtained from a small specimen composed of a close group of individuals averaging 20 millimeters in diameter. The type was measured from five of the smaller of these measuring 5 millimeters in diameter which were conspicuously brighter, sharper and better developed than the larger elements of the group. The type is the most complex of those studied representing no less than 17 forms in combination. In many respects it suggests the combination described by Hessenberg, but lacks the basal pinacoid figured by him, and combines many forms not previously noted from the locality. Crystallographically these crystals appear to be related to those of type I, the presence of three scalenohedrons in the zone $[40\bar{4}1.02\bar{2}1]$ as compared with one of the same zone on type I suggesting this relation. It is believed by the writer that the scalenohedron $2R\frac{11}{4}$ $(15.7.\overline{22}.4)$ described by Hessenberg[1] as new to the species, consists of the two scalenohedrons $\mathfrak{l}$: $(39.15.\overline{54}.8)$ and $\mathfrak{S}$: $(15.7.\overline{22}.2)$. A comparison of the measured and calculated angles for these three forms will indicate the grounds upon which this contention is based. Hessenberg gives for $2R\frac{11}{4}$:

[1] Figure 5, plate 3, is copied from Hessenberg.

	Edge X			Edge Y			Edge Z		
measured	81	53		35	26		33	7	
calculated	81	34	28	35	29	57	33	17	42

The corresponding angular values for 𝔏: $(39.15.\overline{54}.8)$ and 𝔖: $(15.7.\overline{22}.2)$ are as follows:

	Edge X		Edge Y		Edge Z	
39.15.54.8 measured	87	15	30	39	34	59
calculated	87	$14\frac{1}{2}$	30	$46\frac{1}{2}$	34	25
15.7.22.2 measured			37	14	25	22
calculated	83	50	36	5	25	33

From this it will be seen that the edge Y of $(15.7.\overline{22}.2)$ and the edge Z of $(39.15.\overline{54}.8)$ are respectively close to the edges Y and Z of $2R^{\frac{11}{4}}$ of Hessenberg and that both of the former forms which were determined from the averaging of a number of readings for every angle agree closely with the theoretical values. The scalenohedron 𝔏: $(39.15.\overline{54}.8)$ which is new to the species lies closer to the zone $[62\overline{8}1.1101]$ than $2R^{\frac{11}{4}}$. The Naumann symbols for these substituted forms are:

$$39.15.\overline{54}.8 = 3R^{\frac{9}{4}} \text{ and}$$
$$15.7.\overline{22}.2 = 4R^{\frac{11}{4}}$$

Prisms. The prism b $(10\overline{1}0)$ occurs as a series of bright, sharply defined faces in the rhombohedral zone well developed in habit. The prism a was noted as a series of very narrow planes beveling the basal edges of 𝔍: $(62\overline{8}1)$ and principally observed in measuring the zone $[20\overline{2}\overline{1}.02\overline{2}1]$ on crystal 10.

Pyramid. The pyramid $\gamma\,(8.8.\overline{16}.3)$ is present lying in zone between $(21\overline{3}1)$ and the new negative scalenohedron $(4.6.\overline{10}.1)$. The faces are narrow but very brilliant and susceptible of exact determination.

Rhombohedrons. The rhombohedral zone in this type is particularly rich in forms. The rhombohedrons p. $(10\overline{1}1)$ and m. $(40\overline{4}1)$, persistent throughout the occurrence, are present as well developed forms, the former

developed to the extent of a crystal habit. The positive rhombohedron n. (50$\bar{5}$1) occurs as a series of narrow faces beveling the obtuse polar angle of the scalenohedron Ξ: (14.2.$\overline{16}$.3). Two negative rhombohedrons ν· (05$\bar{5}$4) and ξ· (04$\bar{4}$3) appear as slightly developed forms lying between the negative rhombohedrons φ· (02$\bar{2}$1) and δ.(01$\bar{1}$2) sometimes the one form being present and sometimes the other. Both of the forms were noted, however, on one of the crystals measured, indicating the presence of both forms on the type. The negative rhombohedron φ· (02$\bar{2}$1) is present as a well developed form, emphasizing, as in the case of type II the zone [10$\bar{1}$1.02$\bar{2}$1]. The negative rhombohedron δ· (01$\bar{1}$2) is occasionally present as a series of narrow faces.

Scalenohedrons. A series of positive scalenohedrons in the zone [40$\bar{4}$1.11$\bar{2}$0] is developed as a series of large and brilliant planes constituting some of the dominant forms of this habit. The scalenohedron $\mathfrak{J}$: (62$\bar{8}$1) in this zone is here represented in medium development and the rare scalenohedron Ξ: (14.2.$\overline{16}$.3) is represented by a series of narrow and somewhat roughened faces beveling the edges between (40$\bar{4}$1) and (62$\bar{8}$1). This latter form was found by Cesàro[1] on the calcite crystals from Rhisnes and by Palache[2] on those from the copper mines of Lake Superior.

The new positive scalenohedron $\mathfrak{l}$· (39.15.$\overline{34}$.8) is found on crystals of this type developed to a considerable habit. The faces of this scalenohedron which are smooth and bright admitted of measurement to a considerable degree of accuracy and despite the somewhat complex indexes the form appears to be established beyond question.

The common scalenohedron K:(21$\bar{3}$1) here appears as a form of comparatively small development. It is, however, important as marking the intersection of the zones [40$\bar{4}$1.02$\bar{2}$1], [10$\bar{1}$1.11$\bar{2}$0] and [04$\bar{4}\bar{1}$.8.8.$\overline{16}$.3.4.6.$\overline{10}$.1].

The negative scalenohedron q: (24$\bar{6}$1) and ϑ: (4.6.$\overline{10}$.1) noted under type II are also present on this type, though in somewhat smaller development. The combination representing this habit is shown in figure 4.

[1] Cesàro, G. Soc. Geol. Belg. Ann. 1889. 16:229.

[2] Palache, C. Geol Sur. Mich. 1900. 6: 2:168.

Type IV [pl. 4, fig. 1]. Crystals of this type are, in general, larger than those of types II and III, crystal 4, which was the largest one measured, being 40 millimeters in diameter. They are more scalenohedral in habit than those of the foregoing types, the scalenohedrons of the zone $[10\bar{1}1.11\bar{2}0]$ being specially prominent. The habit is essentially different from any of those figured by Zippe, Hessenberg or Dana and appears to have escaped the notice of these writers, probably through lack of characteristic specimens.

Prisms. Both prisms b $(10\bar{1}0)$ and a $(11\bar{2}0)$ are present as well developed forms, the latter represented by broad bright faces, much striated parallel to the zonal edges of $[10\bar{1}1.11\bar{2}0]$.

Pyramids. The pyramid $\gamma\,(8.8.\overline{16}.3)$ noted under type III is here present as a form of more pronounced habit, from the faces of which excellent reflections of the goniometer signal were obtained.

Rhombohedrons. The positive rhombohedron p. $(10\bar{1}1)$ and m. $(40\bar{4}1)$ are here developed in about equal habit, the suppression of the p. planes being specially characteristic of the type. Several planes of the positive rhombohedron c. $(80\bar{8}1)$ reported by Cesàro[1] from Rhisnes but included in lists of Irby[2] and Rogers[3] as doubtful, appear on crystals 6 and 8, and seem to establish the form beyond question. The positive rhombohedron t. $(16.0.\overline{16}.1)$ appeared on five of the eight crystals measured, in every case giving measured values of the angle with the cleavage planes which differed only slightly from theory.

The negative rhombohedrons φ. $(02\bar{2}1)$ ν. $(05\bar{5}4)$ and ξ. $(04\bar{4}3)$ observed on type III are here entirely absent but the form δ. $(01\bar{1}2)$ only occasionally present on the crystals of the previous type is here noted as a fairly well developed series of planes.

Scalenohedrons. The scalenohedrons found upon crystals of this type, for the most part lie in the zone $[10\bar{1}1.11\bar{2}0]$, giving to this zone a prominence

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[1] Cesàro, G. Soc. Géol. Belg. Ann. 1889. 16:165.

[2] Irby, J. R. McD. On the Crystallography of Calcite. Inaug. Dissert. Bonn. 1878.

[3] Rogers, A. F. List of Crystal Forms of Calcite. Sch. of Mines Quar. 1901. 22:429.

quite characteristic of the type. The planes of w:$(31\bar{4}5)$ which modify the vertical terminations are in most cases well developed but dull, and gave poor reflections. A positive scalenohedron in this zone was noted between $(10\bar{1}1)$ and $(21\bar{3}1)$. From several measurements on crystal 2, this scalenohedron seemed to agree closely with H:$(31\bar{4}2)$ but the form could not be established to the writer's satisfaction and is not included in the list although, for the sake of preserving the crystal habit, it is indicated from these indexes on the figure illustrating the type.

The positive scalenohedron K:$(21\bar{3}1)$ is here developed as a series of broad faces of maximum brilliancy supplying excellent points of reference in this zone. The positive scalenohedron T:$(43\bar{7}1)$ occurs as a series of narrow, striated and somewhat rounded faces lying between $(21\bar{3}1)$ and $(11\bar{2}0)$. The form is well established on four of the eight crystals measured.

The positive scalenohedron $\mathfrak{J}$: $(62\bar{8}1)$ is here developed to about the same extent as in type III. The faces are rough and although the form was well established the measurements varied rather more than in the case of the previous types.

A twinned crystal of this type yielded also the negative scalenohedron $\mathfrak{X}$: $(4.16.\overline{20}.3)$, the positive scalenohedron $\mathfrak{Y}$: $(19.10.\overline{29}.6)$ and the positive rhombohedron k. $(11.0.\overline{11}.1)$. The latter two must be regarded as doubtful.

Plate 4, figure 1 represents an average crystal of this habit. The stereographic projection, plate 5, figure 1, shows the interesting zonal relations between the forms occurring on the four types.

The distribution of the forms is given in the following table.

SUMMARY OF DISTRIBUTION OF FORMS

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	TYPE I	TYPE II	TYPE III	TYPE IV	
o	oP	0001	x	....	....	....	
a	∞P	$11\bar{2}0$	x	....	....	....	
b	∞R	$10\bar{1}0$	....	....	x	x	
γ	$\frac{16}{3}$P2	$8.8.\overline{16}.3$	....	....	....	x	
t.	+16R	$16.0.\overline{16}.1$	....	....	....	x	
c.	+8R	$80\bar{8}1$	....	....	....	x	
q.	+7R	$70\bar{7}1$	x	....	....	....	
n.	+5R	$50\bar{5}1$	....	....	x	....	
m.	+4R	$40\bar{4}1$	x	x	x	x	
p.	R	$10\bar{1}1$	x	x	x	x	
δ.	$-\frac{1}{2}$R	$01\bar{1}2$	....	....	x	x	
ν.	$-\frac{5}{4}$R	$05\bar{5}4$	....	....	x	....	
ξ.	$-\frac{4}{3}$R	$04\bar{4}3$	....	....	x	....	
φ.	-2R	$02\bar{2}1$	x	x	x	....	
w:	$+\frac{2}{5}$R2	$31\bar{4}5$	....	....	....	x	
f:	$+\frac{5}{11}$R$\frac{9}{5}$	$7.2.\bar{9}.11$	....	x	....	....	
K:	+R3	$21\bar{3}1$	....	x	x	x	
T:	+R7	$43\bar{7}1$	....	....	....	x	
𝔮:	-2R3	$24\bar{6}1$	....	x	x	....	
𝔰:	-2R5	$4.6.\overline{10}.1$	....	x	x	....	new
𝔛:	-4R$\frac{5}{3}$	$4.16.\overline{20}.3$	....	....	....	x	
Ξ:	+4R$\frac{4}{3}$	$14.2.\overline{16}.3$	....	....	x	....	
𝔍:	+4R2	$62\bar{8}1$	x	x	x	x	
𝔖:	+4R$\frac{11}{4}$	$15.7.\overline{22}.2$	....	....	x	....	
𝔩:	+3R$\frac{9}{4}$	$39.15.\overline{54}.8$	....	....	x	....	new

SUMMARY OF MEASURED AND CALCULATED ANGLES

Type I

LETTER	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
p. : o	$10\bar{1}1 : 0001$	1	44	35	44	$36\frac{1}{2}$
p. : m.	$10\bar{1}1 : 40\bar{4}1$	5	31	13	31	$10\frac{1}{2}$
p. : q.	$10\bar{1}1 : 70\bar{7}1$	4	37	9	37	9
p. : φ.	$10\bar{1}1 : 20\bar{2}\bar{1}$	2	72	$15\frac{1}{2}$	72	$16\frac{1}{2}$
m. : m′.	$40\bar{4}1 : 04\bar{4}\bar{1}$	2	65	$43\frac{1}{2}$	65	50
q. q: ′.	$70\bar{7}1 : 07\bar{7}\bar{1}$	1	62	11	62	1
a : 𝔍:	$11\bar{2}0 : 62\bar{8}1$	2	17	$45\frac{1}{2}$	17	56

SUMMARY OF MEASURED AND CALCULATED ANGLES (*continued*)

Type II

LETTER	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
p. : m.	$10\bar{1}1 : 40\bar{4}1$	1	31	24	31	10½
p. : f:	$10\bar{1}1 : 7.2.\bar{9}.11$	6	11	15½	11	28
f: : f:′	$7.2.\bar{9}.11 : 9.\bar{2}.\bar{7}.11$	3	14	16	14	23
f: : f:″	$7.2.\bar{9}.11 : 2.7.\bar{9}.\overline{11}$	3	111	30	111	24½
q: : q: ′	$24\bar{6}1 : 6\bar{4}\bar{2}1$	4	37	31	37	30
q: : q: ″	$24\bar{6}1 : 42\bar{6}\bar{1}$	2	30	9	30	39
𝔵: : 𝔵:	$4.6.\overline{10}.1 : \bar{4}.10.\bar{6}.1$	1	72	49	72	36½
𝔵: : 𝔵:	$4.6.\overline{10}.1 : 10.\bar{4}.\bar{6}.1$	3	46	22	46	30
𝔵: : 𝔵:	$4.6.\overline{10}.1 : 6.4.\overline{10}.\bar{1}$	2	18	49½	18	41
m. : K:	$40\bar{4}1 : 21\bar{3}1$	1	19	37	19	24
m. : 𝔍:	$40\bar{4}1 : 8\bar{2}\bar{6}1$	1	15	26	14	59

Type III

LETTER	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
p. : m.	$10\bar{1}1 : 40\bar{4}1$	5	31	13	31	10½
p. : n.	$10\bar{1}1 : 50\bar{5}1$	4	33	57½	33	55½
p. : b	$10\bar{1}1 : 10\bar{1}0$	4	45	21½	45	23
b. : φ.	$10\bar{1}0 : 20\bar{2}\bar{1}$	3	26	57	26	53
p. : ν.	$10\bar{1}0 : 50\bar{5}\bar{4}$	2	84	46	84	26
p. : ξ.	$10\bar{1}0 : 40\bar{4}\bar{3}$	2	83	8	82	39½
b. : δ.	$10\bar{1}0 : 10\bar{1}\bar{2}$	1	63	43	63	45
m. : m.′	$40\bar{4}1 : 04\bar{4}1$	6	65	53	65	50
m. : φ.	$40\bar{4}1 : 02\bar{2}1$	6	57	3½	57	5
a : φ.	$11\bar{2}0 : 02\bar{2}1$	5	39	31½	39	25½
φ. : K:	$02\bar{2}1 : 21\bar{3}1$	6	37	37	37	41
m. : q:	$40\bar{4}1 : 24\bar{6}1$	5	40	1	40	1
m. : γ	$40\bar{4}1 : 8.8.\overline{16}.3$	5	28	58	29	14
𝔵: : 𝔵:	$4.6.\overline{10}.1 : 10.\bar{6}.\bar{4}.1$	2	73	18	72	36
𝔩: : 𝔩:	$39.15.\overline{54}.8 : \overline{39}.54.\overline{15}.8$	4	87	15	87	14½
K: : K:	$21\bar{3}1 : 3\bar{1}\bar{2}1$	2	35	29½	35	36
q: : q:	$24\bar{6}1 : \bar{2}6\bar{4}1$	3	37	34½	37	30
𝔵: : 𝔵:	$4.6.\overline{10}.1 : \bar{4}.10.\bar{6}.1$	1	46	11	46	30
𝔩: : 𝔩:	$39.15.\overline{54}.8 : 54.\overline{15}.\overline{39}.8$	3	30	39	30	46½
Ξ : Ξ:	$14.2.\overline{16}.3 : 16.\bar{2}.\overline{14}.3$	2	12	14	12	55
𝔍: : 𝔍:	$62\bar{8}1 : 8\bar{2}\bar{6}1$	2	27	44	27	31
𝔖. : 𝔖:	$15.7.\overline{22}.2 : 22.\bar{7}.\overline{15}.2$	3	37	14	36	5
𝔩: : 𝔩:	$39.15.\overline{54}.8 : 15.39.\overline{54}.\bar{8}$	6	34	59	34	25
a : q:	$11\bar{2}0 : 24\bar{6}1$	12	15	17	15	19½
a : 𝔵:	$11\bar{2}0 : 4.6.\overline{10}.1$	9	9	42	9	20½
a : Ξ:	$11\bar{2}0 : 14.2.\overline{16}.3$	5	26	8	25	53
a : 𝔍:	$11\bar{2}0 : 62\bar{8}1$	8	17	52	17	56
a : 𝔖:	$11\bar{2}0 : 15.7.\overline{22}.2$	8	12	41	12	46
m. : Ξ:	$40\bar{4}1 : 14.2.\overline{16}.3$	6	6	58½	7	1½
m. : 𝔍:	$40\bar{4}1 : 62\bar{8}1$	11	15	1½	14	59
m. : 𝔖:	$40\bar{4}1 : 15.7.\overline{22}.2$	11	20	8	20	8½

SUMMARY OF MEASURED AND CALCULATED ANGLES (*continued*)

Type IV

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
p. : m.	$10\bar{1}1 : 40\bar{4}1$	8	31	8	31	10½
p. : c.	$10\bar{1}1 : 80\bar{8}1$	5	38	18	38	10
p. : t.	$10\bar{1}1 : 16.0.\overline{16}.1$	10	41	35	41	46
p. : b	$10\bar{1}1 : 10\bar{1}0$	7	45	31	45	23½
b : $\eth$.	$10\bar{1}0 : 10\bar{1}\bar{2}$	2	63	41	63	45
Υ : Υ	$8.8.\overline{16}.3 : 8.8.\overline{16}.\bar{3}$	3	24	38	24	46
·Υ : Υ	$8.8.\overline{16}.3 : 16.\bar{8}.\bar{8}.3$	2	58	24	58	28
K: : K:′	$21\bar{3}1 : \bar{2}3\bar{1}1$	3	75	22	75	22
T: : T:′	$43\bar{7}1 : \bar{4}7\bar{3}1$	1	68	50	68	21
w: : w:′	$31\bar{4}5 : \bar{3}4\bar{1}5$	7	49	46	49	22½
K: : K:^{v}	$2131 : 3\bar{1}\bar{2}1$	2	35	34	35	36
$\mathfrak{J}$: : $\mathfrak{J}$:^{v}	$62\bar{8}1 : 8\bar{2}\bar{6}1$	3	27	27	27	31
w: : w:^{v}	$31\bar{4}5 : 4\bar{1}\bar{3}5$	9	16	10	16	0½
K: : K:	$21\bar{3}1 : 12\bar{3}\bar{1}$	10	47	6½	47	1½
T: : T:	$43\bar{7}1 : 34\bar{7}\bar{1}$	8	22	11	21	7½
$\mathfrak{J}$: : $\mathfrak{J}$:	$62\bar{8}1 : 26\bar{8}\bar{1}$	3	35	9	35	52
m. : m.′	$40\bar{4}1 : 04\bar{4}\bar{1}$	1	65	47	65	50
m. : K:	$40\bar{4}1 : 21\bar{3}1$	1	53	22	53	29½
m. : $\mathfrak{J}$:	$40\bar{4}1 : 62\bar{8}1$	4	14	51	14	59
$\mathfrak{X}$: : $\mathfrak{X}$:^{v}	$4.16.\overline{20}.3 : 20.\overline{16}.\bar{4}.3$	3	21	38	21	30
$\mathfrak{X}$: $\mathfrak{X}$: ″	$4.16.\overline{20}.3 : 16.4.\overline{20}.\bar{3}$	1	41	59	42	27

Twinning

Plate 4, figures 2–6

Twinning parallel to the basal plane is characteristic of the larger crystals of the four types. In many instances, as in figures 2 and 5, the interpenetration of the two individuals results in the lateral development of one of them to the extent of forming deep reentrant angles between the planes of p. The crystal shown in figure 3 on which the basal plane of one individual is developed to a considerable habit, shows a low rim bounding the equilateral triangle formed by the intersection of the base. The inside faces of this rim, which is .5 millimeters high compared with a length of 14 millimeters for each side of the triangle, are formed by the planes of $\eth$. $(01\bar{1}2)$. A similar crystal from Rossie is figured by Dana.[1] Other expres-

[1] Dana, J. D. System of Mineralogy. ed. 5, 1868. p. 676, fig. 579.

sions of the twinning habit are shown in figures 4 and 6; these as well as the twin crystals referred to above are figured as nearly as possible in their true proportions.

Natural etch figures

Plate 5, figures 2–5

Natural etch figures, in some instances of sufficient size to be visible to the naked eye, were noted on the planes of o (0001), p. $(10\bar{1}1)$, m. $(40\bar{4}1)$ 𝔍: $(62\bar{8}1)$ and 𝔩: $(39.15.\overline{54}.8)$ as follows:

Basal pinacoid. The basal pinacoid as developed on a twin crystal of type I is covered with well defined etch pits of the form and arrangement shown in figure 2. The largest of these is 1 millimeter in length. The triangular depressions are bounded by the forms δ. $(01\bar{1}2)$ forming the base of the isosceles triangle, and w: $(31\bar{4}5)$ forming the sides. The acute angle measures 27°. All three orientations of the triangular pits were noted on the basal pinacoid above mentioned.

Rhombohedrons. The planes of the rhombohedron p. $(10\bar{1}1)$ on the above crystal were deeply etched with triangular pits of the outline shown in figure 3. These were studied in detail on some of the smaller crystals of type II which offered a much smoother surface on which to observe them. The etch pits are oriented with their straight sides parallel to the rhombohedral edges and are bounded on the straight sides by planes of p. The curved side is formed by the penetration of a plane or series of planes of slightly steeper inclination than p., possibly by the planes of m. or n. The apparent lack of symmetry with respect to the short diagonal of the rhomb disappears when the etch pits b and c are compared with d, it being highly probable that the two former outlines represent the occilatory influence of one scalenohedral plane.

Minute etch pits of the form shown at e, figure 4, were noted on a well developed plane of the rhombohedron m. $(40\bar{4}1)$ from a small crystal of type III. They are bounded by three figure planes which outline the isosceles triangle and a bottom plane. The vertical angle of the triangular outline measures 83°. The outline suggests the possible identity of the basal figure plane, bottom plane and side planes of the etch pit with the planes of p. $(10\bar{1}1)$, m. $(40\bar{4}1)$ and 𝔍: $(62\bar{8}1)$ in the order named.

Scalenohedrons. The planes of $\mathfrak{J}$: $(62\bar{8}1)$ of the crystal of type III mentioned above are etched with several relatively large pits of the form and orientation shown at f. These are unsymmetric in outline and show a close resemblance to the etch pits noted on the plane $\mathfrak{l}$: $(39.15.\overline{54}.8)$ of the same crystal which are shown at g, figure 5. Considering these two forms of etch pits to be bounded by the same planes, it would seem possible that they are identical with the planes of p. $(10\bar{1}1)$, $\mathfrak{q}$: $(24\bar{6}1)$ and $\mathfrak{s}$: $(4.6.\overline{10}.1)$. It is to be regretted that the bounding planes of these etch figures were too small to admit of angular measurement with the instruments available. The etch pits figured at h and j show a different outline and orientation from the g outlines; they are undoubtedly bounded by the same planes as is also the composite pit occurring on the edge of intersection of the planes $39.15.\overline{54}.8$ and $15.39.\overline{54}.\bar{8}$.

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Plate 6, figures 1–6

The calcite crystals included under this occurrence were obtained from the Sterling iron mine about 2 miles north of Antwerp. They are associated with hematite, dolomite and ankerite, as well as with minute crystals of chalcopyrite and more rarely millerite.

The crystals which are universally rhombohedral in habit, show three types corresponding to the calcite of three generations. Of these the positive rhombohedral habit shown in figure 1 represents the earliest generation which preceded the genetic stage marked by the formation of ankerite and dolomite. An interesting demonstration of this sequence was noted in the case of one specimen which showed several hollow spaces bounded by incrusting dolomite which correspond in outline to the positive rhombohedron p. $(10\bar{1}1)$ and were evidently the result of the resolution of calcite of that habit. The layer of dolomite supported several calcite crystals of low rhombohedral habit, type II, having the negative rhombohedron $\mathfrak{e}$. $(10\bar{1}2)$ for the dominant form.

Type I [fig. 1]. The positive rhombohedral habit characteristic of crystals of the first generation was noted on two specimens and is shown in

figure 1. In crystals of this type lateral edges of the dominant positive rhombohedron p. $(10\bar{1}1)$ are beveled by narrow planes of the positive scalenohedrons K: $(21\bar{3}1)$ and N: $(53\bar{8}2)$ in the zone $[10\bar{1}1.11\bar{2}0]$ the latter of which is not always present. The negative scalenohedron g: $(6.7.\overline{13}.2)$, characteristic of the more complex combinations of the second generation is here present as a well developed form. The basal pinacoid o (0001) was noted on several crystals. A twinning tendency, expressed by striations on the rhombohedral planes parallel to the base was noted on crystals of this type although no actual twins were observed.

Type II [fig. 2–4]. The simplest expression of the low rhombohedral habit combines the negative rhombohedron δ. $(01\bar{1}2)$ with the prism b $(10\bar{1}0)$ and is shown in figure 2. These crystals occur implanted on a mass of secondary crystallized quartz and are evidently of a more advanced genetic stage than those of type I. The largest of them measures 15 millimeters in diameter.

The combination shown in figure 3 was found on the specimen described in an earlier paragraph and is represented by isolated crystals averaging 10 millimeters in diameter. The lateral edges of the dominant rhombohedron $(01\bar{1}2)$ are beveled by narrow faces of the negative scalenohedron g: $(6.7.\overline{13}.2)$. A steep positive rhombohedron v. $(90\bar{9}1)$ is present as a bright and clearly defined series of faces. The combination shown in figure 4 differs from the above only in the fact that the positive rhombohedron v. is here replaced by the somewhat steeper form s. $(13.0.\overline{13}.1)$. The crystal units are almost universally parallel aggregates of two or more individuals which gives to the lateral zone a notched appearance.

Type III [fig. 5, 6]. Crystals of this type were noted on two specimens from the collection of the late Mr Nims of Philadelphia, N. Y. They were evidently collected at a comparatively early period in the history of the mine and differ materially in habit and association from those at present obtainable from this locality. The calcite crystals in this instance line the interior of cavities in the red hematite and are either deposited directly on the latter mineral or separated from it by a thin band of limonite. The

crystals average 5 millimeters in vertical length and are clustered in thick aggregates; in no instance was a doubly terminated individual noted. In habit the crystals are rhombohedral, the dominant form being the negative rhombohedron φ. $(02\bar{2}1)$ modified by a well developed series of forms lying in zone $[01\bar{1}2.10\bar{1}1.11\bar{2}0]$. In the combination shown in figure 5 the positive rhombohedron p. $(10\bar{1}1)$ which truncates the polar edges of φ. is developed as a series of narrow planes of great brilliancy. The combination is terminated by the positive scalenohedron e: $(41\bar{5}6)$, the second order pyramid π $(11\bar{2}3)$ and the negative rhombohedron δ. $(01\bar{1}2)$. The planes of e: are narrow and somewhat striated parallel to the zone; those of π are brilliant and yielded fine reflections. The positive scalenohedron K: $(21\bar{3}1)$ is present as a series of bright, striated planes of fair development. Small, bright planes of the positive rhombohedron m. $(40\bar{4}1)$ were noted on one crystal of this habit. A variation of this type is shown in figure 6 which differs from the combination above described in the greater development of the modifying zone and in the absence of the negative rhombohedron δ.. The crystals of both habits occur intimately associated on the same specimen.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
π : π	$11\bar{2}3 : \bar{1}2\bar{1}3$	10	28	49½	28	39
π : π	$11\bar{2}3 : \bar{1}\bar{1}23$	2	59	40½	59	20
δ. : s.	$01\bar{1}2 : 0.13.\overline{13}.\bar{1}$	10	68	6	68	12½
δ. : v.	$01\bar{1}2 : 09\bar{9}\bar{1}$	6	70	11	70	10½
p. : m.	$10\bar{1}1 : 40\bar{4}1$	1	31	12	31	10½
m. : m.	$40\bar{4}1 : \bar{4}401$	1	114	4	114	10
p. : φ.	$10\bar{1}1 : \bar{2}021$	1	107	46	107	43½
φ. : φ.	$2\bar{2}01 : 02\bar{2}1$	1	101	5	101	9
p. : e:	$10\bar{1}1 : 41\bar{5}6$	5	10	33½	10	24
e: : e:	$41\bar{5}6 : 5\bar{1}\bar{4}6$	3	13	6	13	3½
p. : K:	$10\bar{1}1 : 21\bar{3}1$	3	29	20	29	2
K: : K:	$21\bar{3}1 : 3\bar{1}\bar{2}1$	1	35	46	35	36
p. : N:	$10\bar{1}1 : 53\bar{8}2$	2	34	33	34	28
g⁝ : g⁝	$6.7.\overline{13}.2 : 6.13.\bar{7}.2$	3	53	48	53	58½
g⁝ : g⁝	$6.7.\overline{13}.2 : 7.6.\overline{13}.\bar{2}$	3	21	4	21	1

SOMERVILLE, ST LAWRENCE CO.

Plate 7, figures 1–7

These calcite crystals were collected from the workings of the Caledonia mine about 1 mile east of Somerville, St Lawrence co. The crystals of type V occur associated with hematite on two specimens collected by Mr D. H. Newland. For a fine crystal of type II the writer is indebted to Mr Thomas Cameron. A small series furnishing types I, II, III and IV were collected by Mr R. S. Hodge of Antwerp.

Type I [fig. 1]. Crystals of type I occur deposited on a thin layer of crystallized pyrite lining cavities in the pinkish crystalline limestone of the wall rock. They are rhombohedral in habit, the dominant forms being the fundamental rhombohedron p. $(10\bar{1}1)$ and the negative rhombohedron δ. $(01\bar{1}2)$. Small bright planes of the prism b. $(10\bar{1}0)$ are present in the rhombohedral zone. The lateral edges of p. are modified by brilliant but somewhat rounded planes of the rare second order pyramid $\eta\,(5.5.\overline{10}.1)$, described by Rogers on the calcite from Frizington, England,[1] and by extremely narrow, bright planes of the positive scalenohedrons K: $(21\bar{3}1)$ and N: $(53\bar{8}2)$ in the zone $[10\bar{1}1.11\bar{2}0]$.

Type II [fig. 2]. This type was observed on a single specimen consisting of one large crystal which measured 45 millimeters in vertical hight, and a number of small attached crystals, and on two specimens of the series collected by Mr Hodge. These crystals are evidently of a second stage of generation derived from a previous rhombohedral type which latter appears as a phantom outlined by minute inclusions of pyrite. The presence of phantom crystals of rhombohedral habit appears to indicate the formation of the crystals of type II around a preexisting individual of type I. Crystals of this type show prominent development of the planes of a new pyramid of the second order $\varphi\,(8.8.\overline{16}.1)$. This pyramid, which is the most acute yet observed for calcite, is well defined and corresponds well with previously recorded forms, supplying another member to the series $2P2(11\bar{2}1)$, $4P2(22\bar{4}1)$ and $8P2(44\bar{8}1)$. The relation of the new pyramid

[1] Rogers, A. F. Am. Jour. Sci. 1901. 12: 44.

$16P2 = (8.8.\bar{16}.1)$ to existing forms becomes more apparent when the two principal series of pyramids are arranged in parallel columns thus:

$\frac{2}{3}P2 = (11\bar{2}3)$	$2P2 = (11\bar{2}1)$
$\frac{4}{3}P2 = (22\bar{4}3)$	$4P2 = (22\bar{4}1)$
$\frac{8}{3}P2 = (44\bar{8}3)$	$8P2 = (44\bar{8}1)$
$\frac{16}{3}P2 = (8.8.\bar{16}.3)$	$16P2 = (8.8.\bar{16}.1)$

The prisms b $(10\bar{1}0)$ and a $(11\bar{2}0)$ are present, the former developed to a considerable habit. The crystals are terminated by the planes of the negative rhombohedron $\delta.(01\bar{1}2)$, and the scalenohedron K: $(21\bar{3}1)$.

Type III [fig. 3]. Crystals of type III occur in an association similar to that of type I with the important exception that in this case the thin layer intermediate between the crystallized calcite and the limestone country rock is composed of marcasite. The crystals which average 7 millimeters in vertical length are rhombohedral-prismatic in habit, the dominant forms being the negative rhombohedron $\delta.(01\bar{1}2)$ and the prism b $(10\bar{1}0)$. The rhombohedral zone is comparatively rich in forms; the positive rhombohedrons p. $(10\bar{1}1)$ m. $(40\bar{4}1)$ and s. $(13.0.\bar{13}.1)$ are present, the two former as small but brilliant planes and the latter as a somewhat dull and rounded series of faces. The negative rhombohedron $\eta.(04\bar{4}5)$ is present in fair development, represented by planes of great brilliancy. Two positive scalenohedrons E: $(51\bar{6}4)$ and K: $(21\bar{3}1)$ in the zone $[10\bar{1}1.11\bar{2}0]$ are present as bright series of planes striated parallel to the zone.

Type IV [fig. 4, 5]. Crystals of this type occur associated with chalcopyrite, marcasite and some crystallized quartz in cavities in the limestone which constitutes the country rock. They are somewhat smaller than those of preceding types averaging 5 millimeters in vertical length. In habit they are scalenohedral, the negative scalenohedron g: $(6.7.\bar{13}.2)$, previously noted under the Antwerp occurrence, constituting the dominant form of the combination shown in figure 4. This combination is terminated

by the negative rhombohedron $\delta.(01\bar{1}2)$; the lateral angles of the scalenohedron are truncated by the prism $b\,(10\bar{1}0)$.

The combination shown in figure 5 has for its dominant form the positive scalenohedron $K:(21\bar{3}1)$ terminated by the rhombohedrons $p.\,(10\bar{1}1)$, and $\delta.(01\bar{1}2)$ and the positive scalenohedron $c:(61\bar{7}8)$ all of which lie in the zone $[01\bar{1}2.11\bar{2}0)$ and the two latter of which are deeply striated parallel to the zone. The lateral angles of K: are modified in the negative sextants by the planes of g: $(6.7.\overline{13}.2)$ in fair development.

Type V [fig. 6, 7]. The crystals of this type are found lining the interior of pockets in massive red hematite and incrusting a thin layer of specular hematite which latter appears to be of secondary derivation from the main body of the ore. They average 4 millimeters in vertical length and do not show in any instance a double termination. In habit the crystals of this type vary slightly from a distinctly scalenohedral phase [fig. 6] to a rhombohedral-scalenohedral variation [fig. 7]. The dominant scalenohedron $K:(21\bar{3}1)$ is always present, represented by smooth, bright planes. In the rhombohedral zone, the prism $b\,(10\bar{1}0)$ and the positive rhombohedron $m.\,(40\bar{4}1)$ are dominant, specially in the variation represented in figure 7. On the crystals of this variation the new negative scalenohedron $\mathfrak{e}\,(1.11.\overline{12}.2)$ was noted. This scalenohedron is present as a series of minute faces, which, however, gave fair reflections and corresponded well with theoretical values for the measured angles. The crystals of the combination represented in figure 6 show, as well as the negative rhombohedron $\delta.(01\bar{1}2)$, common to the type, the negative rhombohedrons $\eta.\,(04\bar{4}5)$, $\varphi.\,(02\bar{2}1)$ and $\Phi.\,(0.14.\overline{14}.1)$ all of which latter are developed as subsidiary modifications.

SUMMARY OF DISTRIBUTION OF FORMS

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	
a	$\infty P2$	$11\bar{2}0$	....	x	....	....	....	
b	∞R	$10\bar{1}0$	x	x	x	....	x	
η	10P2	$5.5.\overline{10}.1$	x	....	....	....	....	
φ	16P2	$8.8.\overline{16}.1$	....	x	....	....	....	new
s.	13R	$13.0.\overline{13}.1$	....	....	x	....	....	

SUMMARY OF DISTRIBUTION OF FORMS (*continued*)

LETTER	NAUMAN SYMBOL	BAVAIS-MILLER SYMBOL	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	
m.	4R	$40\bar{4}1$	....	....	x	....	x	
p.	R	$10\bar{1}1$	x	....	x	x	....	
δ.	$-\frac{1}{2}R$	$01\bar{1}2$	x	x	x	x	x	
η.	$-\frac{4}{5}R$	$04\bar{4}5$	....	....	x	....	x	
φ.	$-2R$	$02\bar{2}1$	....	....	....	....	x	
Φ.	$-14R$	$0.14.\overline{14}.1$	....	....	....	....	x	
c:	$+\frac{5}{8}R\frac{7}{5}$	$61\bar{7}8$	....	....	....	x	....	
E:	$+R\frac{3}{2}$	$51\bar{6}4$	....	....	x	....	....	
K:	$+R3$	$21\bar{3}1$	x	x	x	x	x	
M:	$+R\frac{11}{3}$	$7.4.\overline{11}.3$	x	....	....	....	....	
g:	$-\frac{1}{2}R13$	$6.7.\overline{13}.2$	....	....	....	x	....	
e	$-5R\frac{6}{5}$	$1.11.12.2$	....	....	....	....	x	new

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
$\eta : \eta$	$5.5.\overline{10}.1 : 5.5.\overline{10}.\bar{1}$	6	13	17	13	22
$\varphi : \varphi$	$8.8.\overline{16}.1 : 8.8.\overline{16}.\bar{1}$	5	8	49	8	22
$\varphi : \varphi$	$8.8.\overline{16}.1 : 16.\bar{8}.\bar{8}.1$	1	59	22	59	38½
b : s.	$10\bar{1}0 : 13.0.\overline{13}.1$	3	4	32	4	27½
δ. : m.	$01\bar{1}2 : 04\bar{4}1$	7	102	11	102	2
p. : m.	$10\bar{1}1 : 40\bar{4}1$	3	31	12	31	10½
δ. : η.	$01\bar{1}2 : 04\bar{4}5$	11	12	20	12	2
δ. : φ.	$01\bar{1}2 : 02\bar{2}1$	1	36	57	36	52
δ. : Φ.	$01\bar{1}2 : 0.14.\overline{14}.1$	5	59	31	59	36½
c: : c:	$61\bar{7}8 : \bar{6}7\bar{1}8$	2	59	49	59	46
c: : c:	$61\bar{7}8 : 7\bar{1}\bar{6}8$	1	9	31	9	31½
E: : E:	$51\bar{6}4 : \bar{5}6\bar{1}4$	1	77	45	77	54
E: : E:	$51\bar{6}4 : 6\bar{1}\bar{5}4$	2	14	23½	14	27
p. : E:	$10\bar{1}1 : 51\bar{6}4$	3	11	32	11	31
K: : K:	$21\bar{3}1 : \bar{2}3\bar{1}1$	5	75	19	75	22
K: : K:	$21\bar{3}1 : 3\bar{1}\bar{2}1$	2	35	40½	35	36
p. : K:	$10\bar{1}1 : 21\bar{3}1$	5	29	12	29	2
M: : M:	$7.4.\overline{11}.3 : 11.\bar{4}.\bar{7}.3$	1	40	29	40	4
p. : M:	$10\bar{1}1 : 7.4.\overline{11}.3$	3	33	5	32	57
g: : g:	$6.7.\overline{13}.2 : 13.\bar{7}.\bar{6}.2$	2	63	25	63	57
g: : g:	$6.7.\overline{13}.2 : \bar{6}.13.\bar{7}.2$	3	54	30	53	58
δ. : g:	$01\bar{1}2 : 6.7.\overline{13}.2$	2	56	39	56	58
e : e	$1.11.\overline{12}.2 : 12.\overline{11}.\bar{1}.2$	5	109	½	108	53
e : e	$1.11.\overline{12}.2 : \bar{1}.12.\overline{11}.2$	7	8	32	8	30

CALCITE FROM STERLINGBUSH, LEWIS CO., N. Y.

Plate 8

Early in October 1906, the attention of the Assistant State Geologist was directed to several fine calcite crystals in the possession of Miss Pauline Sterling in Antwerp. These proved on investigation to have come from the quarry of the New York Lime Co., about 1 mile east of Sterlingbush in the town of Diana, Lewis co. The quarry was situated on the eastern slope of a ridge of dolomitic limestone extending northeast and southwest, the exposed face rising to a hight of about 35 feet. At a hight of approximately 20 feet from the base of this exposed face, the limestone had been hollowed out to form an irregular shaped cavern, the wall, roof and floor of which were covered with calcite crystals some of which were of enormous size. At the time of the visit a portion of the walls of this cave had been removed in the operation of quarrying the limestone. Access to the cave was gained through an opening about 4 feet in diameter. Inside this opening the cavity expanded to a cross section of about 10 feet in width by 5 feet in hight, running back for a distance of some 20 feet when it suddenly contracted to a small passage about 4 feet in cross section, rather winding, but extending downward in a general direction for a distance of about 20 feet, gradually narrowing to a size which rendered it impossible of access.

Many of the largest crystals were found in the outer portion of the cave, the roof and walls of which were thickly covered with calcite crystals of all sizes. Fewer and smaller crystals were encountered in the inner cave where they were found mostly attached to the roof and sides.

The crystals are of unusual size, the largest taken out measuring 3 feet 7 inches by 3 feet 1½ inches by 1 foot 6 inches and weighing approximately 1000 pounds.[1] A number of smaller crystals ranging in weight from 100 to 500 pounds were obtained besides several large slabs covered with smaller crystals and a vast amount of smaller specimens representing single crystals

[1] The largest calcite crystal of which a record is accessible is one from Eskifjördhr, Iceland, at present in the British Museum.

and groups. In all about 6 tons of material of exceptional beauty and interest were taken from this locality.

In habit the calcite crystals resemble those from Rossie, St Lawrence co., a locality situated about 20 miles northwest of Sterlingbush and in a limestone area similar in character, age and general trend.

The basal pinacoid o (0001), which is universally present, is strikingly developed on all the larger crystals. The planes of this form are smooth, of medium brilliancy and covered, in many instances, by triangular pits produced by a tendency to form parallel grouping. The rhombohedron p. $(10\bar{1}1)$ is also universally present but unequally developed. In some instances, as in the case of the larger crystals, it becomes the dominant form producing a distinctly rhombohedral type. A series of scalenohedrons in the zone $[10\bar{1}1:01\bar{1}2]$ bevels the lateral edges of the primative rhombohedron. This series in the above mentioned zone tends to reflect the goniometer signal as a broad band, some 9° in width, from which specially luminous points were selected and the readings repeated on 17 of the most brilliant of the smaller crystals. These luminous points correspond to the scalenohedrons K: $(21\bar{3}1)$, E: $(9.5.\overline{14}.4)$, N: $(53\bar{8}2)$ and P: $(32\bar{5}1)$. Considerable vicinal development mars the sharpness of these forms and gives to the zone between these limits a somewhat rounded aspect. On one crystal two faces of the scalenohedron T $(42\bar{6}1)$ were found, developed to considerable brilliancy and sharpness. This crystal is shown in figure 1, and may be taken as an average expression of the habit of the larger crystals. Figure 2 shows a crystal of scalenohedral habit typical of the calcite incrusting the roof and walls of the outer cavern. These average from 1 to 4 centimeters in vertical length and show in addition to the forms already mentioned the negative rhombohedron φ. $(02\bar{2}1)$ developed as a series of small brilliant planes.

The large crystals show a strong tendency toward the formation of penetration twins parallel to a composition face o. This twinning habit finds expression in deep reentrant angles or "channels," well shown in figure 4, and produced by corresponding planes of p. $(10\bar{1}1)$ in twinned position.

On a number of crystals repeated twinning according to this law was noted, in one instance as many as four repetitions of the twinning habit being observed [fig. 5]. The abnormal development of the basal plane produces a tabular aspect quite characteristic of the occurrence. Some expressions of the twinning habit are shown in figures 3, 4, 5 and 6.

Many of the crystals which were found lying loose on the floor of the innermost portion of the cavern were completely developed on all sides, showing no point of attachment. This fact which is sufficiently remarkable in crystals of this size may lead to some interesting speculations as to the manner of their production and the character of the crystallizing solution. Many of the largest crystals obtained from the outer cave were attached to the wall by a relatively small portion of their total surface so that it was possible to detach them by very little effort.

One of the most striking characters of these crystals is a delicate amethystine to pink color shown on a large percentage of the specimens and which renders them singularly beautiful. The color appears to be irregularly distributed throughout the mass and shows deeper in the outer portions of the crystals. A tendency toward the concentration of color parallel to definite planes, notably the planes of cleavage, was noted. Calcite crystals similar in color have recently been found in the Maybell mine at North Empire, Kansas, and have been described by Sterrett,[1] who notes a similar lack of uniformity in the distribution of color. A dendritic deposit of pyrolusite observed on the termination of some of the small crystals from the outer cave indicates the derivation of the color from a minute percentage of manganese.

Secondary aragonite occurs as an incrustation of minute acicular crystals on some of the calcite representing an early generation. Some quartz was noted associated with the calcite of this stage. Although considerable stalactitic calcite was observed coating the surface of the large crystals, very little evidence of true stalactitic formation was to be found

[1] Sterrett, D.B. A new Type of Calcite from the Joplin Mining District. Am. Jour. Sci. 1904. 18 : 73.

on the roof, walls and floor of the cavern. One slender stalactite which measured 12.8 centimeters in length and .5 centimeters in diameter was hollow for about one third of its length and was lined with crystallized calcite. This, together with the remarkable size of the calcite crystallization, points to a condition of extremely slow deposition of lime carbonate from a solution which must have remained undisturbed during the entire process of crystal deposition.

The secondary twinning parallel to a hypothetic plane $(01\bar{1}2)$ which has been noted in connection with the calcite from Crown Point,[1] is developed to a marked degree on the Sterlingbush crystals where it takes the form of parallel systems of sharp ridges protruding from the surfaces of the planes of both p. and o. [Fig. 5]. On one crystal, the basal plane of which measures 15.6 centimeters on the bounding edges, one of these projections measures 4 centimeters in length and .5 centimeters in hight. The significance of the presence of two twinning habits developed to such a degree in calcite crystals from localities so far removed as Sterlingbush and Crown Point, gains added force from the fact that both localities occur in bodies of crystalline limestone of the Grenville series.

Much praise is due Mr C. A. Hartnagel, assistant in geology, for his energy and enthusiasm shown in the collection of this valuable accession to the museum collections.

LYON MOUNTAIN, CLINTON CO.

Plates 9–12

These calcite crystals were collected from the Chateaugay mines situated at Lyon Mountain in Clinton county, about 23 miles west of Plattsburg and near the northern boundary of the area of Adirondack gneiss which forms the main outlying mass of the Adirondacks. The workings consist of a series of inclined shafts which in some instances extend to a vertical depth of 800 feet. It was for the most part in the deeper levels of the mine that the openings or " vugs " were encountered which furnished the greater mass of the material collected.

[1] *See* page 97.

Most of the calcite specimens of types III, IV and V were obtained from a still larger vug which formerly extended across the ore body and was excavated previous to the writer's visit. Much of the material collected from the dump heaps also showed evidence of the same vug formation.

The several phases which mark the deposition of secondary calcite are characterized by calcite crystals of definite habit. Of these crystal types, the first two stand distinctly apart from a genetic point of view, whereas the last three are more or less closely related both from the standpoint of crystal genesis and habit.

Type I [pl. 9, fig. 1–3]. Crystals of this type are found directly associated with the corroded quartz orthoclase and amphibole, in most instances deposited as a crust upon a highly corroded surface. They are distinctly scalenohedral in habit, the steep scalenohedron U:$(54\bar{9}1)$ predominating, modified in termination by the rhombohedrons m. $(40\bar{4}1)$ and J. $(0.13.\bar{1}\bar{3}.4)$. Figures 1, 2 and 3 show this habit. The rhombohedron m. is present in a bright series of planes which furnished excellent points of reference. The rhombohedron J., on the other hand, gave faint but distinct reflections from a series of dull and somewhat rounded surfaces. On several specimens the rhombohedron p. $(10\bar{1}1)$ is prominent in crystals of this habit. Several times during the measurement of crystals of this type, a narrow plane beveling the acute polar edges of U: $(54\bar{9}1)$ was observed. A rhombohedron in this zone would have the indexes $(0.13.\bar{1}\bar{3}.2)$, a form which seems doubly probable in consideration of the fact that the presence of $(0.13.\bar{1}\bar{3}.4)$ has already been noted with reference to this type. No satisfactory reading could, however, be obtained.

Crystals which measure from 3 millimeters to 25 millimeters in length are, in some instances filled with microscopic inclusions of quartz, hematite and matted byssolite, the latter forming a central nucleus of irregular shape, while the hematite, which was connected with a later stage of the crystal growth, appears in the outer layers in dendritic bunches.

Regarding the generation of calcite of this type it must unquestionably be placed at the base of the calcite series as shown at Lyon Mountain.

The marked absence of pyramidal forms in the crystal habit and the presence of two modifying rhombohedra, entirely absent from the varied types found in the later calcite deposition, set it distinctly apart as marking a separate genetic phase. At the same time the close association with primary minerals which show evidences of corrosion, points to the origin of this type from a highly corrosive crystallizing solution, rich in carbonate of lime but still far from saturated with silica and iron.

Type II [pl. 9, fig. 4]. Calcite crystallizing in the forms of type II occurs incrusting the surface of joints in the ore body, in a confused aggregate of translucent, milky white crystals which exhibit none of the tendency toward parallel grouping of separate individuals noticeable in other types from this locality. The manner of the crystal massing suggests rapid deposition from a solution whose condition of concentration had been influenced by a sudden cooling, change of pressure or some allied cause. Such a change of condition of concentration seems highly probable in the case of an open joint filled or partly filled with the crystallizing solution which from the nature of the case would be far more sensitive to the influence of currents.

The crystals of this type which average 7 millimeters in diameter, are rhombohedral in habit and composed of " built up " forms, the predominating negative rhombohedron being deeply grooved by incipient modifications parallel to (0001) and ($01\bar{1}2$). The rhombohedron Y. ($0.19.\overline{19}.13$) is present as a series of moderately brilliant but somewhat rounded faces; the form was determined by averaging the readings taken on 20 of the best crystals available. The scalenohedron q: ($24\bar{6}1$) is present, beveling the basal edges of the predominating rhombohedron. Indications pointed to a second scalenohedron in this zone giving the indexes ($10.16.\overline{26}.3$) and beveling the basal edges of q: as thin lines from which measurements were obtained with great difficulty. The form must be regarded as doubtful.

Type III [pl. 9, fig. 5; pl. 10]. Calcite crystallizing in forms of this type differs from those previously described both in mode of occurrence and habit. They occur for the most part embedded in masses of bys-

solite and are often free or so loosely attached that doubly terminated individuals are readily obtained. They are of a later generation than those of type I. In habit they are essentially pyramidal, the simpler development showing the predominance of two pyramids in the same series, $\gamma\,(8.8.\bar{16}.3)$ and $\lambda(22\bar{4}3)$ [plate 9, figure 5]. More complex variations of this habit [pl. 10, fig. 1, 2] are found associated with these secondary minerals and, indeed, the remaining types to be discussed may be said to represent phases of the same conditions of deposition, as they are, at the same time, modified expressions of the same crystal habit. The combination shown in plate 9, figure 5 represents this habit in its simplest development and is found in crystals varying from 2 to 5 millimeters in vertical length. The pyramid $\gamma\,(8.8.\bar{16}.3)$ occurs as a series of bright, sharp faces. The faces of the pyramid $\lambda\,(22\bar{4}3)$ and of the rhombohedron Y. $(0.19.\bar{19}.13)$ are of fair brilliancy but frequently roughened by natural etchings. The planes of K: $(21\bar{3}1)$ are often present on this combination but of relatively small development. On two crystals a terminating scalenohedron in the zone $[0.19.\bar{19}.13.19.\bar{19}.0.13]$ gave measurements roughly corresponding to $(7.2.\bar{9}.11)$ but on account of the imperfect nature of the reflections the form must be regarded as doubtful.

The combinations shown in plate 10, figures 1 and 2 are variations of the above habit, observed on different specimens. Of these the combination shown in figure 1 is characterized by the development of small but brilliant planes of the negative scalenohedron ϑ: $(4.6.\bar{10}.1)$. This scalenohedron was first observed on the calcite from Rossie.[1] The combination illustrated in figure 2 differs from figure 1 in the relatively large development of the planes in the zone of the negative rhombohedrons. The negative rhombohedrons $\sigma.(0.11.\bar{11}.7)$ and $\Sigma.(0.11.\bar{11}.1)$ are present as deeply etched planes giving relatively poor reflections. The combination shown in figure 3 represents a modification of this habit in which the planes of the scalenohedron K: $(21\bar{3}1)$ partly replace those of λ, and a second negative rhombohedron $\eta.(04\bar{4}5)$ terminates the crystal partly replacing the planes of Y. The alternate polar edges of γ are beveled by the scalenohedron $\mathfrak{U}\,(14.12.\bar{26}.5)$

[1] *See* pages 62 and 64.

in the zone [8.8.$\overline{16}$.3.16.8.$\bar{8}$.3]. This combination which seems to indicate a slower and more perfect stage of crystallization occurs in larger crystals than those previously described under this type, detached crystals measuring from 4 millimeters to 30 millimeters in vertical length. A variation of this combination which tends to connect the pyramidal habit of this type with type V is shown in figure 4. Here the negative rhombohedron σ. (0.11.$\overline{11}$.7) of figure 2 is present, as well as the much commoner form φ. (02$\bar{2}$1), the latter developed to much the same habit as in type V, where its occurrence is repeated. A series of well developed planes of the prism b (10$\bar{1}$0) is also present in this combination, lying in zone with γ and the new negative scalenohedron t: (8.14.$\overline{22}$.3), which latter form falls well at the intersection of the zones [8.8.$\overline{16}$.3.01$\bar{1}$0] and [02$\bar{2}$1.11$\bar{2}$0]. In the zone of the second order pyramids, besides the pyramids λ (22$\bar{4}$3) and γ (8.8.$\overline{16}$.3), common to the type, the rare pyramid ν (11$\bar{2}$1) occurred on one crystal represented by two small but relatively bright planes. This pyramid was first noted by Palache[1] on the calcite crystals from Lake Superior; its presence on a crystal of this type seems somewhat anomalous inasmuch as the dominant pyramid series for the occurrence consists of $\frac{2}{3}$P2, $\frac{4}{3}$P2, $\frac{8}{3}$P2 and $\frac{16}{3}$P2. It is, however, notable in this connection that the 2P2 pyramid in question is situated not only in the zone of the second order pyramids but also in the zone [02$\bar{2}$1.3$\bar{1}\bar{2}$1] both of which are extremely well defined in crystals of this combination.

A new negative scalenohedron t: (8.14.$\overline{22}$.3) in the zone [02$\bar{2}$1.11$\bar{2}$0] is here present as a series of well developed but relatively dull planes. The form was established by its presence in the above mentioned zone and by its measured angular distance from φ. (02$\bar{2}$1), an excellent reference point in the zone.

The dihexagonal prism θ (21$\bar{3}$0) is present as a series of very narrow but brilliant faces in zone with the planes of a (11$\bar{2}$0), the latter form being also represented by very narrow faces.

A combination shown in figure 5 was present on one specimen. This

[1] Palache, C. Geol. Sur. Mich. 1900. 6:167.

differs from those preceding in the much greater development of the planes of the negative rhombohedron φ.$(02\bar{2}1)$, which here amounts to almost a rhombohedral habit, and in the presence of the negative rhombohedron ν. $(05\bar{5}4)$, a form hitherto unnoted in the occurrence. The scalenohedron K: $(21\bar{3}1)$ common to the majority of the other crystals of this type is absent from this combination.

Type IV [pl. 11, fig. 1–3]. Figure 1 shows a combination resulting from the development of the negative rhombohedron ξ. $(04\bar{4}3)$ which here replaces the planes of the pyramids λ and γ to the extent of giving to crystals of this phase a rhombohedral aspect. The pyramids γ $(8.8.\overline{16}.3)$ and λ $(22\bar{4}3)$ which connect this combination with type III are present as faces of great brilliancy, as are also the planes of K:$(21\bar{3}1)$. The rhombohedron ξ. $(04\bar{4}3)$ here replaces Y. as a series of brilliant planes which yield excellent reflections. Genetically this type corresponds closely with type III, the crystals occurring with considerable secondary quartz embedded in chlorite also of the second generation. The crystals are clear and faintly yellow in color and measure from 6 to 10 millimeters on the vertical axis.

A curious variation of this type was noted on a large mass of hornblende which was thickly incrusted with albite crystals.[1] These calcite crystals were symmetrically disposed in parallel position on the six basal angles of a positive rhombohedron p. $(10\bar{1}1)$, the latter evidently of a previous growth and considerably etched and roughened on the surface. One of these composite crystals is shown in figure 3 and an enlargement of one of the superposed secondary crystals in figure 2. The secondary crystals of this phase bear a general resemblance to the modified combination of type III [pl. 10, fig. 3] in that they show the scalenohedron 𝔘 $(14.12.\overline{26}.5)$ beveling the alternate polar edges of the prevailing pyramid γ $(8.8.\overline{16}.3)$. The pyramid π $(11\bar{2}3)$ in the same series with those previously noted appears as a terminal modification consisting of deeply striated faces. The scalenohedron U: $(54\bar{9}1)$ of type I here reappears for the first time as a series of small

[1] The writer is indebted to Mr H.H. Hindshaw for the loan of this handsome specimen as well as for material taken from it for study.

but brilliant faces. The negative scalenohedron q: $(24\bar{6}1)$ characteristic of type II is here represented by small brilliant faces; from both of these latter forms excellent reflections were obtained. The two pyramids $\lambda(22\bar{4}3)$ and $\gamma(8.8.\bar{16}.3)$ are developed as large faces, the former giving fair reflections from somewhat dull surfaces, and the latter bright and sharp reflections. The three pyramids lie well in zone and agree closely as to measured and calculated angles. The composite crystals as shown in figure 3 vary in size from 4 millimeters to 30 millimeters in diameter measured on a basal axis. The superposed crystals frequently unite to form a band encircling the primitive rhombohedron, which latter in many instances shows incipient forms of this habit irregularly disposed on the rhombohedral planes in parallel position; these latter, however, are microscopic and only serve to accentuate the characteristic grouping habit.

Type V [pl. 11, fig. 4]. Crystals of this type were noted on a single specimen, which differed little, with respect to the association and general deposition of the secondary minerals, from the specimens producing types III and IV, but which showed a much lower percentage of secondary quartz crystals than these latter. Several small crystals of transparent apatite were noted on this specimen. In habit these crystals are far more complex than any hitherto described from this locality, the combination shown in figure 4 consisting of no less than 11 forms. In size and brilliancy they also exceed the previously described types averaging 12 millimeters in vertical length and beautifully developed in clear and sharp faces, all of which, with the exception of $\eta.(04\bar{4}5)$, gave fine reflections of the goniometer signal. In general, indications seem to connect this type with a slower action of the crystallizing solution producing more perfect and highly modified individuals.

A clearly marked rhombohedral zone consisting of $\eta.(04\bar{4}5)$, $\xi.(04\bar{4}3)$, $\varrho.(02\bar{2}1)$, $\Delta.(07\bar{7}2)$ and $\Sigma.(0.11.\bar{11}.1)$ characterizes the crystals of this type, the faces of which are small but clearly defined. $\gamma(8.8.\bar{16}.3)$, the predominating pyramid of types III and IV, is wholly lacking from this

combination, its place being taken by $\alpha(44\bar{8}3)$ a form not hitherto noted from this locality but which completes the series of pyramids by supplying a logical link in the sequence between $(22\bar{4}3)$ and $(8.8.\overline{16}.3)$ the former of which is present as a highly developed series of planes giving very fair reflections. Two negative scalenohedrons, q: $(24\bar{6}1)$, which was also noted in types II and IV, and c: $(34\bar{7}2)$, are present as large and well developed forms. The positive scalenohedrons K: $(21\bar{3}1)$ and $\mathfrak{K}$: $(8.4.\overline{12}.1)$ are present as well developed forms. A regular and symmetrical roughening was noted on the obtuse polar edges of K: $(21\bar{3}1)$ as shown in figure 4 which was probably due to some twinning tendency,[1] although no twins were observed in connection with this type.

The complex zonal relations between the various forms occurring on the calcite from Lyon Mountain are shown in the stereographic projection, plate 12, and are particularly well illustrated in the combinations of type V which includes 11 of the 27 forms observed for the locality. Assuming the principle announced by Cesàro[2] "that when a crystal of calcite is formed around a preexisting crystal, in general the edges of the first crystal tend to be replaced by faces which are parallel to them; i. e. a face of the new crystal is in zone with two faces of the original one." The superposed groups of type IV present a striking instance of harmony in zonal relations, and indeed the gradual increase in the numbers of forms from type I through types III, IV and V shows a close coincidence with Cesàro's principle.

[1] In this connection it is interesting to note that the calculated values of φ for $(21\bar{3}1)$ and $(42\bar{6}\bar{1})$ are the same and that consequently a penetration twin parallel to (0001) would bring the superposed planes of these two forms in close orientation and might result in a vicinal roughening similar to that observed.

[2] Cesàro, G. Les formes crystallines de la Calcite de Rhisnes. Ann. de la Soc. Géol. de Belgique. 1889. 16:167.

SUMMARY OF DISTRIBUTION OF FORMS

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	
a	$\infty P2$	$11\bar{2}0$	....	....	x	....	....	
b	∞R	$10\bar{1}0$	....	....	x	....	....	
θ	$\infty R3$	$21\bar{3}0$	....	....	x	....	....	
π	$\frac{2}{3}P2$	$11\bar{2}3$	....	....	....	x	....	
λ	$\frac{4}{3}P2$	$22\bar{4}3$	....	....	x	x	x	
ν	$2P2$	$11\bar{2}1$	....	....	x	....	....	
α	$\frac{8}{3}P2$	$44\bar{8}3$	....	....	....	....	x	
γ	$\frac{16}{3}P2$	$8.8.\bar{16}.3$	....	....	x	x	....	
m.	$4R$	$40\bar{4}1$	x	....	....	....	....	
p.	R	$10\bar{1}1$	x	....	x	....	....	
η.	$-\frac{4}{5}R$	$04\bar{4}5$	....	....	x	....	x	
ν.	$-\frac{5}{4}R$	$05\bar{5}4$	....	....	x	....	....	
ξ.	$-\frac{4}{3}R$	$04\bar{4}3$	....	....	....	x	x	
Y.	$-\frac{19}{13}R$	$0.19.\bar{19}.13$	....	x	x	....	....	
σ.	$-\frac{11}{7}R$	$0.11.\bar{11}.7$	....	....	x	....	....	
ρ.	$-2R$	$02\bar{2}1$	....	....	x	....	x	
J.	$-\frac{13}{4}R$	$0.13.\bar{13}.4$	x	....	....	....	....	
Λ.	$-\frac{7}{2}R$	$07\bar{7}2$	....	....	....	....	x	
Σ.	$-11R$	$0.11.\bar{11}.1$	....	....	....	....	x	
K:	$R3$	$21\bar{3}1$	....	....	x	x	x	
U:	$R9$	5491	x	....	....	x	....	
t:	$-2R\frac{11}{3}$	$8.14.\bar{22}.3$	....	....	x	....	....	new
𝔮:	$-2R3$	$24\bar{6}1$	....	x	....	x	x	
𝔖:	$-2R5$	$4.6.\bar{10}.1$	....	....	x	....	....	new
𝔲	$\frac{2}{3}R13$	$14.12.\bar{26}.5$	....	....	x	x	....	
𝔎:	$4R3$	$8.4.\bar{12}.1$	....	....	....	....	x	
c:	$-\frac{1}{2}R7$	$34\bar{7}2$	....	....	....	....	x	

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	SYMBOL	TYPE	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
θ	$21\bar{3}0$	III	$11\bar{2}0 : 21\bar{3}0$	4	10	39	10	53
π	$11\bar{2}3$	IV	$11\bar{2}3 : 2\bar{1}\bar{1}3$	6	28	15	28	39
			$11\bar{2}3 : 8.8.\bar{16}.3$	1	47	37	47	57
λ	$22\bar{4}3$	III	$22\bar{4}3 : 4\bar{2}\bar{2}3$	2	44	2	44	$8\frac{1}{2}$
		IV	$22\bar{4}3 : 4\bar{2}\bar{2}3$	1	44	12	44	$8\frac{1}{2}$
		V	$22\bar{4}3 : 4\bar{2}\bar{2}3$	2	44	$10\frac{1}{2}$	44	$8\frac{1}{2}$
		III	$22\bar{4}3 : 8.8.\bar{16}.3$	6	28	48	28	54
		IV	$22\bar{4}3 : 8.8.\bar{16}.3$	3	28	$52\frac{1}{2}$	28	54

SUMMARY OF MEASURED AND CALCULATED ANGLES *(continued)*

LETTER	SYMBOL	TYPE	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
ν	$11\bar{2}1$	III	$11\bar{2}1 : 8.8.\bar{16}.3$	2	17	58½	17	57
α	$44\bar{8}3$	V	$44\bar{8}3 : 8\bar{4}\bar{4}3$	1	54	23	54	30
		V	$44\bar{8}3 : 21\bar{3}1$	2	10	26	10	27
γ	$8.8.\bar{16}.3$	III	$8.8.\bar{16}.3 : 16.\bar{8}.\bar{8}.3$	3	58	28	58	28
		IV	$8.8.\bar{16}.3 : 16.\bar{8}.\bar{8}.3$	1	58	33	58	28
		III	$8.8.\bar{16}.3 : 8.8.\bar{16}.\bar{3}$	4	24	37	24	46
		IV	$8.8.\bar{16}.3 : 8.8.\bar{16}.\bar{3}$	2	24	40	24	46
m.	$40\bar{4}1$	I	$40\bar{4}1 : 01\bar{1}\bar{1}$	5	31	16½	31	10½
η.	$04\bar{4}5$	V	$04\bar{4}5 : 01\bar{1}\bar{1}$	2	96	46	97	7
ν.	$05\bar{5}4$	III	$05\bar{5}4 : 01\bar{1}\bar{1}$	1	83	54	84	26
ξ.	$04\bar{4}3$	IV	$04\bar{4}3 : \bar{4}043$	[a]15	87	13	87	10
		IV	$04\bar{4}3 : 01\bar{1}\bar{1}$	1	82	47	82	38½
		V	$04\bar{4}3 : 01\bar{1}\bar{1}$	3	82	41½	82	38½
Y.	$0.19.\bar{19}.13$	II	$0.19.\bar{19}.13 : \bar{19}.0.19.13$	10	90	45	90	44
		III	$0.19.\bar{19}.13 : \bar{19}.0.19.13$	9	90	31½	90	44
		II	$0.19.\bar{19}.13 : 0\bar{1}11$	10	99	41½	99	51½
		III	$0.19.\bar{19}.13 : 0\bar{1}11$	9	99	49½	99	51½
σ.	$0.11.\bar{11}.7$	III	$0.11.\bar{11}.7 : 0\bar{1}11$	1	101	59	101	47
φ.	$02\bar{2}1$	III	$02\bar{2}1 : \bar{2}021$	3	79	29	79	51
		III	$02\bar{2}1 : 01\bar{1}\bar{1}$	2	72	13	72	17
		V	$02\bar{2}1 : 01\bar{1}\bar{1}$	3	72	9⅓	72	17
J.	$0.13.\bar{13}.4$	I	$0.13.\bar{13}.4 : 0\bar{4}41$	4	148	27	148	28
Δ.	$07\bar{7}2$	V	$07\bar{7}2 : 0\bar{1}11$	1	118	34	118	27½
Σ.	$0.11.\bar{11}.1$	V	$0.11.\bar{11}.1 : 01\bar{1}\bar{1}$	2	50	42	50	39½
K:	$21\bar{3}1$	III	$21\bar{3}1 : \bar{2}3\bar{1}1$	1	75	18	75	22
		V	$21\bar{3}1 : \bar{2}3\bar{1}1$	1	75	15	75	22
		III	$21\bar{3}1 : 3\bar{1}\bar{2}1$	3	35	36	35	39
		V	$21\bar{3}1 : 3\bar{1}\bar{2}1$	1	35	43	35	39
		III	$21\bar{3}1 : 12\bar{3}\bar{1}$	1	47	17	47	1½

[a]Measurement made with contact goniometer.

SUMMARY OF MEASURED AND CALCULATED ANGLES (*continued*)

LETTER	SYMBOL	TYPE	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
U:	$54\bar{9}1$	I	$54\bar{9}1 : \bar{5}9\bar{4}1$	7	66	$46\frac{1}{2}$	66	$42\frac{1}{2}$
		I	$54\bar{9}1 : 9\bar{4}\bar{5}1$	10	52	$5\frac{1}{2}$	52	11
		IV	$54\bar{9}1 : 9\bar{4}\bar{5}1$	1	52	35	52	11
		I	$54\bar{9}1 : 459\bar{1}$	6	16	29	16	30
t:	$8.14.\overline{22}.3$	III	$02\bar{2}1 : 8.14.\overline{22}.3$	6	26	47	26	47
		III	$8.14.\overline{22}.3 : 14.8.\overline{22}.\bar{3}$	2	25	26	25	17
q:	$24\bar{6}1$	II	$24\bar{6}1 : \bar{2}6\bar{4}1$	3	80	1	80	$1\frac{1}{2}$
		II	$24\bar{6}1 : 6\bar{4}\bar{2}1$	5	37	21	37	30
		IV	$24\bar{6}1 : 6\bar{4}\bar{2}1$	1	37	38	37	30
		V	$24\bar{6}1 : 6\bar{4}\bar{2}1$	3	37	26	37	30
		II	$24\bar{6}1 : 42\bar{6}\bar{1}$	9	30	48	30	39
		IV	$24\bar{6}1 : 42\bar{6}\bar{1}$	2	30	$41\frac{1}{2}$	30	39
		V	$42\bar{6}\bar{1} : 21\bar{3}1$	1	31	42	31	49
𝔖:	$4.6.\overline{10}.1$	III	$4.6.\overline{10}.1 : 10.\bar{6}.\bar{4}.1$	4	46	29	46	30
		III	$4.6.\overline{10}.1 : 21\bar{3}1$	2	22	$6\frac{1}{2}$	22	10
𝔘	$14.12.\overline{26}.5$	III	$14.12.\overline{26}.5 : \overline{14}.26.\overline{12}.5$	2	63	$10\frac{1}{2}$	63	19
		III	$14.12.\overline{26}.5 : 26.\overline{12}.\overline{14}.5$	4	53	$38\frac{1}{2}$	53	34
		III	$14.12.\overline{26}.5 : 12.14.\overline{26}.\bar{5}$	5	25	$4\frac{1}{2}$	25	46
		IV	$14.12.\overline{26}.5 : 12.14.\overline{26}.\bar{5}$	1	25	48	25	46
𝔎:	$8.4.\overline{12}.1$	V	$8.4.\overline{12}.1 : 12.\bar{4}.\bar{8}.1$	1	38	4	38	2
		V	$8.4.\overline{12}.1 : 4.8.\overline{12}.\bar{1}$	1	24	17	24	21
		V	$8.4.\overline{12}.1 : 21\bar{3}1$	1	15	37	15	30
c:	$34\bar{7}2$	V	$34\bar{7}2 : 37\bar{4}2$	2	65	34	65	24
		V	$34\bar{7}2 : 43\bar{7}\bar{2}$	2	47	43	47	$48\frac{1}{2}$

ARNOLD HILL, CLINTON CO

Plate 13, figures 1–4

A few specimens of crystallized calcite were obtained from the Arnold Hill mines. At this locality the calcite occurs in veins traversing the syenitic gneiss which constitutes the country rock and is commonly associated with pyrite in small crystals and with red jasper, which latter mineral marks an earlier stage of vein deposition. Small brilliant scales

of specular hematite occur on one specimen associated with and evidently of the same generation as the calcite crystals of type I.

Type I [fig. 1, 2]. Crystals of this type are characterized by a prismatic habit developed to the extent shown in figure 1, terminated by the common negative rhombohedron $\delta.(01\bar{1}2)$. A positive scalenohedron of the zone $[10\bar{1}1.11\bar{2}0]$ modifies the solid angles in the positive sextants. The measured angles of this scalenohedron differ slightly from those of the common form $P:(32\bar{5}1)$. This difference, although small, is sufficiently constant and consistent as to indicate a new scalenohedron in this zone having the symbols $R^{2,4}_{5} = (29.19.\bar{48}.10)$. The presence of a scalenohedron so near R5 appears so irrational that the series of measurements upon which this contention is based is herewith appended for comparison together with the calculated angles for the assumed form and for those nearest to it in zone

angle $Y = h\ k\ \bar{i}\ 1 : i\ \bar{k}\ \bar{h}\ 1$

MEASURED		CALCULATED					
$R^{2,4}_{5}$ =		$(29.19.\bar{48}.10)$		R5 = $(32\bar{5}1)$		$R^{1,4}_{3}$ $(17.11.\bar{28}.6)$	
°	′	°	′	°	′	°	′
44	50	44	55	45	32	44	28
44	16						
44	52						
Angle $\frac{1}{2}$ $Z = h\ k\ \bar{i}\ 1 : 11\bar{2}0$							
14	39						
14	58						
14	59						
15	5						
15	6	15	13	14	38	17	30
15	13						
15	14						
15	21						
15	24						
13	36						

A variation of the type differing somewhat from the combination shown in figure 1 appears on extremely minute crystals which constitute a druse lining the walls of a thin seam on one specimen. These crystals, which average .5 millimeter in diameter are shown in figure 2. They are distinctly rhombohedral in habit, the prism a $(11\bar{2}0)$ is reduced to a series of narrow planes and the prism b (1010) is entirely lacking. The new scalenohedron r: $(29.19.\overline{48}.10)$ is considerably more prominent than in the former combination. A negative scalenohedron, the planes of which bevel the acute polar edges of $(29.19.\overline{48}.10)$ and which lies nearly but not quite in zone with the planes of the latter form, gave measurements which corresponded to p: $(13\bar{4}1)$. This relation adds weight to the contention that the positive scalenohedron in question differs slightly in position from R5. which latter form would lie exactly in the above zone. The letter r: has been assigned to this form.

Type II [fig. 3]. Crystals of this type appear on one specimen furnished by Mr Hindshaw. They form a close aggregate deposited on a thin layer of pyrite and average 13 millimeters in diameter. The crystal units are apparently compound parallel groupings which take the general form shown in figure 3. This type is rhombohedral in habit, the prevailing rhombohedron being δ. $(01\bar{1}2)$. The middle edges of this rhombohedron are replaced by the faces of the negative scalenohedron e: $(9.11.\overline{20}.4)$ and the prism a $(11\bar{2}0)$ and the lateral solid angles by the prism b $(10\bar{1}0)$. The faces of the rhombohedron in many instances are entirely composed of minute steep scalenohedral crystals having e: for the dominant form, and clearly marking the compound character of the crystal units. Drusy surfaces of the specimen furnished minute single individuals showing the scalenohedral habit illustrated in figure 3a.

Type III [fig. 4]. Crystals of this type were noted on a single specimen collected by the writer in 1906. They occur in thick aggregates deposited directly on the syenitic gneiss of the country rock. The crystals average 3 millimeters in vertical length and in many instances are doubly terminated. In habit they are scalenohedral, the dominant form being the positive

scalenohedron T: $(43\bar{7}1)$ in the zone $[10\bar{1}1.11\bar{2}0]$. This scalenohedron is terminated by the basal plane o (0001) and is modified on the basal edges by planes of the prism a $(11\bar{2}0)$. Both of the latter forms are well developed; all the faces of this combination gave fair reflections of the goniometer signal.

The forms noted on the three types of the occurrence are:

a $(11\bar{2}0)$, b $(10\bar{1}0)$, ẟ. $(01\bar{1}2)$, r: $(29.19.\overline{48}.10)$, new, T: $(43\bar{7}1)$, 𝔭: $(13\bar{4}1)$ and e: $(9.11.\overline{20}.4)$.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
r: : r:	$29.19.\overline{48}.10 : 48.\overline{19}.\overline{29}.10$	3	44	38	44	55
r: : a	$29.19.\overline{48}.10 : 11\bar{2}0$	10	15	8½	15	13
T: : T:	$43\bar{7}1 : \bar{4}7\bar{3}1$	4	68	30½	68	21
T: : T	$43\bar{7}1 : 7\bar{3}\bar{4}1$	5	49	46	49	50
𝔭: : 𝔭:	$13\bar{4}1 : \bar{1}4\bar{3}1$	1	26	26	26	44½
𝔭: : a	$13\bar{4}1 : 11\bar{2}0$	5	22	14	22	21
e: : e:	$9.11.\overline{20}.4 : \bar{9}.20.\overline{11}.4$	1	51	30	51	33
e: : ẟ.	$9.11.\overline{20}.4 : 01\bar{1}2$	6	53	39	53	55

MINEVILLE, ESSEX CO.

Plate 13, figures 5, 6

Small crystals of calcite occur on several specimens from the Cook shaft, Fischer hill, Mineville, which were collected by Dr John C. Smock and which form part of a large series illustrating New York iron ores. The crystals which average 8 millimeters in vertical length form a secondary deposit in veins in gneiss, the latter more or less thickly impregnated with magnetite. As in the case of the Arnold Hill calcite veins the primary vein filling consists of cryptocrystalline quartz of a jasper phase which lies in immediate contact with the walls of the veins. In most instances the secondary calcite completely fills the remaining space, the crystals interlocking in the center. Crystals suitable for determination were obtained from the thick aggregates which protrude into the open spaces formed by the widening of the veins. In no instance were doubly terminated individuals obtainable.

The crystals are scalenohedral in habit strongly suggesting type I of Lyon Mountain. The dominant form is the positive scalenohedron V:(6.5.$\overline{11}$.1) in the zone [10$\bar{1}$1.11$\bar{2}$0], a form which approaches closely to U:(54$\bar{9}$1) of type I Lyon Mountain.[1] The shorter polar edges of V:are truncated by the planes of the negative rhombohedron Π.(0$\bar{8}$81) present as a series of somewhat rounded but readily distinguishable faces.

The planes of the negative rhombohedron φ.(02$\bar{2}$1), which forms the termination of this habit, are roughened by vicinal planes in the rhombohedral zone and gave rather poor reflections of the goniometer signal. Consistent readings were obtained, however, which taken in conjunction with the fact that the faces of this form lie in zone with those of the positive rhombohedron p.(10$\bar{1}$1) establishes its identity. The planes of p.(10$\bar{1}$1) although minute are extremely brilliant and furnished excellent points of reference. Figures 5 and 6 show crystals of this occurrence. Figure 5 represents a phase common to the larger and figure 6 to the smaller crystals.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
p. : Π.	0$\bar{1}$11 : 0$\bar{8}$81	8	126	3⅓	126	23½
p. : φ.	0$\bar{1}$11 : 0$\bar{2}$21	2	107	54½	107	43½
φ. : φ.′	0$\bar{2}$21 : $\bar{2}$021	3	101	1⅓	101	9
V: : V:′	6.5.$\overline{11}$.1 : $\bar{6}$.11.$\bar{5}$.1	4	65	9½	65	35½
V: : V:^{v}	6.5.$\overline{11}$.1 : 11.$\bar{5}$.$\bar{6}$.1	4	53	32	53	40

CHILSON LAKE, ESSEX CO.

Plate 14, figures 1-4

The material from which this occurrence was studied was obtained in June 1907 from the mine of the Crown Point Graphite Co. which is situated ½ mile north of Chilson Lake. The calcite is, in general, associated with pyrite and graphite, the latter minerals lining the walls of the seams in parallel bands interspaced with the calcite which formed the

[1] *See* page 82.

ultimate vein filling. On one specimen calcite crystals of the tabular rhombohedral habit were associated with compact druses of natrolite in small but determinable crystals.

Type I. Crystals of this type are rhombohedral in habit and present two phases which are frequently present together superposed in parallel position. Of these, the first phase consists of the negative rhombohedron $\rho.\ (03\bar{3}2)$ which, when present alone, is terminated by the pinacoid o (0001) as shown in figure 1. The crystals average 5 millimeters in diameter and are colorless, milky white or light yellow in color.

The crystals of the second phase are tabular parallel to the pinacoid o which is bounded by the planes of the negative rhombohedron $\varphi.\ (02\bar{2}1)$. These average 20 millimeters in diameter, measured on the basal plane, by 2 millimeters in vertical thickness. The combination of a crystal of the second phase surmounted by one or more crystals of the first phase in parallel position is quite common and is shown in figure 2. In the composite crystals the rhombohedron $\rho.$ is never terminated, the transparent, colorless individual protruding from the basal plane of the milky white crystal of the second phase. On one large specimen, crystals averaging 15 millimeters in diameter were noted which exhibit the habit shown in figure 3. These are thickly incrusted on the basal plane with small individuals of the first phase. They are translucent and light yellow in color.

Type II. Crystals of type II which are semitransparent and average 5 millimeters in diameter apparently represent a later genetic stage. They are rhombohedral in habit the dominant form being the negative rhombohedron $\varkappa.\ (01\bar{1}1)$. The planes of this rhombohedron are much roughened by vicinal prominences. The prism b $(10\bar{1}0)$ is present as a well developed series of bright planes and the prism a $(11\bar{2}0)$ as a series of bright planes of small development. The negative rhombohedron $\varphi.\ (02\bar{2}1)$ of type I is occasionally present.

The positive scalenohedrons N: $(53\bar{8}2)$ in the zone $[10\bar{1}1.11\bar{2}0]$ and the negative scalenohedron $\mathbf{o}$: $(2.8.\overline{10}.3)$ in the zone $[02\bar{2}1.11\bar{2}0]$ are present as well developed forms giving fair reflections. Figure 4 shows a combination of this type.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
o : ϱ.	$0001 : 03\bar{3}2$	4	56	1	55	57
ϱ.″ : ϱ.	$3\bar{3}02 : 03\bar{3}2$	2	87	56	88	18
o : φ.	$0001 : 02\bar{2}1$	4	62	56½	63	7
a : φ.	$11\bar{2}0 : 02\bar{2}1$	2	39	4	39	26½
ϰ.″ : ϰ.	$1\bar{1}01 : 01\bar{1}1$	1	74	40	74	55
p. : b	$10\bar{1}1 : 10\bar{1}0$	3	45	36	45	23½
N: : N:	$53\bar{8}2 : \bar{5}8\bar{3}2$	1	72	59	72	54½
N: : N:	$53\bar{8}2 : 8\bar{3}\bar{5}2$	2	41	29½	41	46
N: : a	$53\bar{8}2 : 11\bar{2}0$	4	18	48	18	4
$\mathfrak{o}$⁝ : $\mathfrak{o}$⁝	$2.8.\overline{10}.3 : \bar{2}.10.\bar{8}.3$	1	20	50	20	40
$\mathfrak{o}$⁝ : a	$2.8.\overline{10}.3 : 11\bar{2}0$	2	26	2	26	15

CROWN POINT, ESSEX CO.

Plate 14, figure 5

Large rhombohedral crystals of calcite were obtained from the locality formerly worked for eupyrchroite which is situated ¾ of a mile southeast of Crown Point. These crystals are bounded by the unmodified planes of the fundamental rhombohedron p. $(10\bar{1}1)$ twinned parallel to the basal plane. They average 12 centimeters in diameter, the surfaces being dull and for the most part covered with a thin stalactitic deposit of calcite, specially on the edges. They resemble the crystals from Sterlingbush in their strong twinning tendency and are furthermore, in many instances, covered with low projecting planes of p. twinned parallel to the negative rhombohedron δ. $(01\bar{1}2)$.

SMITH'S BASIN, WASHINGTON CO.

Plates 15, 16

These calcite crystals were collected from the quarries of the Keenan Lime Co. situated about ½ mile east of Smith's Basin. The calcite occurs in veins traversing the Trenton limestone in the southern quarry which latter shows numerous "slickenslides" and other evidences of faulting. The material available for study consists of a suite of 18 specimens from which a series of 31 crystals illustrating the three types was selected.

Type I [pl. 15, fig. 1]. The crystals of this type are extremely

minute, averaging 2 millimeters in vertical length. They are scalenohedral in habit, the dominant form being the positive scalenohedron ι:(17.15.$\overline{32}$.2) in the zone [10$\overline{1}$1.11$\overline{2}$0]. This is, in many instances, terminated by the planes of the negative rhombohedron δ.(10$\overline{1}$2) in relatively small development. The scalenohedral faces are smooth and brilliant, yielding good reflections of the goniometer signal. Type I evidently marks an early stage of crystal deposition and corresponds genetically with the prismatic habit to be discussed under type II. The crystals occur in narrow seams in the limestone and are deposited directly on the wall rock. No instance of double termination was noted.

Type II [pl. 15, fig. 2, 3]. Crystals presenting the two combinations of this type were noted on the same specimen which furnished type I. The combination shown in figure 2 is represented by small brilliant crystals of prismatic habit averaging 2 millimeters in vertical length. In the prismatic zone the new dihexagonal prism μ (53$\overline{8}$0) is present, developed to a considerable habit, the axial edges being beveled by narrow planes of the prism a (11$\overline{2}$0). All the planes in this zone are sharp and brilliant giving good reflections. In the rhombohedral zone the negative rhombohedron φ.(02$\overline{2}$1) is a conspicuous form of this habit, the negative rhombohedrons ψ.(05$\overline{5}$2) and Ξ.(05$\overline{5}$1) are present in comparatively small development. Narrow planes of the positive rhombohedron p.(10$\overline{1}$1) truncate the polar edges of φ. furnishing excellent points of reference in the zone. The positive scalenohedron ω:(15.13.$\overline{28}$.2) in the zone [10$\overline{1}$1.11$\overline{2}$0] and close to ι:(17.15.$\overline{32}$.2) of type I is present as a series of well developed planes. The separate identity of these two forms which was at first a subject of doubt was satisfactorily established by a series of careful measurements of the polar angles for both forms, the measurements showing but little variation in either form.

The rhombohedral-scalenohedral habit shown in figure 3 is referable to this type mainly on genetic grounds, the habit occurring in close association with prismatic combination described above. The dominant form of this habit is the positive scalenohedron θ:(9.7.$\overline{16}$.2) in the zone [10$\overline{1}$1.11$\overline{2}$0],

a form related in series to ι: of type I, which is present as a series of bright, well developed planes giving good reflections. In the rhombohedral zone the rhombohedrons φ. $(02\bar{2}1)$, ψ. $(05\bar{5}2)$ and p. $(10\bar{1}1)$ noted on the prismatic habit are present, the two latter developed to a rather more considerable habit. The positive rhombohedron m. $(40\bar{4}1)$ is here present as a series of small bright faces. Small, well developed planes of the negative scalenohedron r: $(35\bar{8}1)$ in the zone $[11\bar{2}0.02\bar{2}1]$ are present, modifying the acute polar edges of θ:. On the whole the combinations of types I and II appear to be more closely interrelated than those of the succeeding types and may almost be considered as representing a single genetic phase.

Type III [pl. 15, fig. 4]. The crystals of type III are in general larger than those of the preceding types, averaging 15 millimeters in vertical length, and occur in close parallel aggregates. They are characterized by a decided tendency to formation of vicinal planes specially in the rhombohedral zone where a vicinal series of planes marks the passage from the negative rhombohedron φ. $(02\bar{2}1)$ to the prism b $(10\bar{1}0)$. Both of these forms are somewhat ill defined and were noted in the limits of the above series. The positive scalenohedron ℜ: $(8.4.\overline{12}.1)$ is present as a series of well developed planes of fair brilliancy. The positive scalenohedron P: $(32\bar{5}1)$ in the zone $[10\bar{1}1.11\bar{2}0]$ and the negative scalenohedron r: $(35\bar{8}1)$ in the zone $[11\bar{2}0.02\bar{2}1]$ are present as well developed forms giving fair reflections. Crystals of this type although of a later generation than those of type II retain the steep rhombohedral habit entirely lacking in type IV and appear in a measure to link together the two generations of calcite crystals of this occurrence.

Type IV [pl. 15, fig. 5, 6]. The crystals of this type are in size and number by far the most prominent of the occurrence, particularly with respect to the rhombohedral habit shown in figure 6. Crystals of this latter habit occur on all the specimens comprising the suite and in some instances attain a diameter of 8 centimeters. In general the type is distinguished by the prominence of the negative rhombohedron δ. $(01\bar{1}2)$, a form absent from the three preceding types, and by the presence of the prisms a $(11\bar{2}0)$ and b $(10\bar{1}0)$ in considerable development.

In the rhombohedral zone the negative rhombohedrons δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$ and Σ. $(0.11.\overline{11}.1)$ are present, the latter only on crystals of the rhombohedral habit. Two positive scalenohedrons of the zone $[10\bar{1}1.11\bar{2}0]$, M: $(7.4.\overline{11}.3)$ and P: $(32\bar{5}1)$ are present on crystals of the rhombohedral habit, the former of which is also present in larger development on the prismatic-rhombohedral crystals [fig. 5]. The planes of these forms are striated parallel to the zone yielding only fair reflections. The positive scalenohedron ℜ: $(8.4.\overline{12}.1)$ and the negative scalenohedron 𝔭: $(13\bar{4}1)$ are present as modifying planes of comparatively small development on crystals of the prismatic-rhombohedral type. The faces are of moderate brilliancy and yield fair reflections. Crystals of this type evidently represent an advanced stage of crystal deposition and may be regarded as the latter end of the genetic series.

The zonal relations of occurring forms is shown in the stereographic projection, plate 16. The distribution of forms with respect to the four types is given in the following table:

SUMMARY OF DISTRIBUTION OF FORMS

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	TYPE I	TYPE II	TYPE III	TYPE IV	
a.	∞P2	$11\bar{2}0$	....	x	....	x	
b.	∞R	$10\bar{1}0$	....	....	x	x	
μ	∞R4	$53\bar{8}0$	....	x	....	....	new
m.	4R	$40\bar{4}1$	....	x	....	....	
p.	R	$10\bar{1}1$	....	x	....	....	
δ.	$-\frac{1}{2}$R	$01\bar{1}2$	x	....	....	x	
φ.	—2R	$02\bar{2}1$	....	x	x	x	
ψ.	$-\frac{5}{2}$R	$05\bar{5}2$	....	x	....	....	
Ξ.	—5R	$05\bar{5}1$	....	x	....	....	
Σ.	—11R	$0.11.\overline{11}.1$	....	....	....	x	
M:	$R\frac{11}{3}$	$7.4.\overline{11}.3$	....	....	....	x	
P:	R5	$32\bar{5}1$	....	....	x	x	
θ:	R8	$9.7.\overline{16}.2$	....	x	....	....	
ω:	R14	$15.13.\overline{28}.2$	....	x	....	....	
ι:	R16	$17.15.\overline{32}.2$	x	....	....	....	
𝔭:	—2R2	$13\bar{4}1$	....	....	....	x	
𝔯:	—2R4	$35\bar{8}1$	....	x	x	....	
ℜ:	4R3	$8.4.\overline{12}.1$	....	....	x	x	

SUMMARY OF MEASURED AND CALCULATED ANGLES

	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
a : μ	$11\bar{2}0 : 53\bar{8}0$	14	7	58	8	13
p. : m.	$10\bar{1}1 : 40\bar{4}1$	2	31	7	31	11½
δ. : b	$01\bar{1}2 : 01\bar{1}0$	3	64	3½	63	45
δ. : φ.	$01\bar{1}2 : 02\bar{2}1$	6	36	55½	36	52
p. : ψ.	$0\bar{1}11 : 05\bar{5}2$	4	112	30	112	32½
φ. : Ξ.	$02\bar{2}1 : 05\bar{5}1$	1	15	36	15	25
δ. : Σ.	$01\bar{1}2 : 0.11.\overline{11}.1$	4	58	13	58	29
M: : M:	$7.4.\overline{11}.3 : \bar{7}.11.\bar{4}.3$	2	73	56	73	40
M: : M:	$7.4.\overline{11}.3 : 11.\bar{4}.\bar{7}.3$	4	40	19	40	4
a : M:	$11\bar{2}0 : 7.4.\overline{11}.3$	4	19	36	19	35½
P: : P:	$32\bar{5}1 : \bar{3}5\bar{2}1$	3	70	47⅔	70	59
P: : P:	$32\bar{5}1 : 5\bar{2}\bar{3}1$	2	45	14	45	52
a : P:	$11\bar{2}0 : 32\bar{5}1$	4	14	24	14	37
θ: : θ:	$9.7.\overline{16}.2 : \bar{9}.16.\bar{7}.2$	5	67	4	67	26½
θ: : θ:	$9.7.\overline{16}.2 : 16.\bar{7}.\bar{9}.2$	5	51	27	51	9½
θ: : p.	$9.7.\overline{16}.2 : 10\bar{1}1$	1	43	15	43	16½
ω: : ω:	$15.13.\overline{28}.2 : \overline{15}.28.\overline{13}.2$	6	64	23	64	28
ω: : ω:	$15.13.\overline{28}.2 : 28.\overline{13}.\overline{15}.2$	5	55	13½	55	4
ι: : ι:	$17.15.\overline{32}.2 : \overline{17}.32.\overline{15}.2$	3	63	55	63	56½
ι: : ι:	$17.15.\overline{32}.2 : 32.\overline{15}.\overline{17}.2$	3	55	40	55	42½
a : $\mathfrak{p}$:	$1120 : 13\bar{4}1$	5	22	34½	22	21
$\mathfrak{r}$: : $\mathfrak{r}$:	$35\bar{8}1 : \bar{3}8\bar{5}1$	4	75	8	75	30
$\mathfrak{r}$: : $\mathfrak{r}$:	$35\bar{8}1 : 8\bar{5}\bar{3}1$	3	44	46	45	6
$\mathfrak{K}$: : $\mathfrak{K}$:	$8.4.\overline{12}.1 : \bar{8}.12.\bar{4}.1$	1	80	57	81	20
$\mathfrak{K}$: : $\mathfrak{K}$:	$8.4.\overline{12}.1 : 12.\bar{4}.\bar{8}.1$	8	38	22½	38	2
a : $\mathfrak{K}$:	$8.4.\overline{12}.1 : 11\bar{2}0$	5	12	8	12	10½

GLENS FALLS, WARREN CO.

Plate 17, figures 1, 2

Several specimens of crystallized calcite were collected from a limestone quarry ¼ mile southwest of Glens Falls. The calcite here occurs in thin veins in compact Trenton limestone associated with some crystallized quartz which latter mineral is found embedded in the vein calcite. The crystals which vary in size from 2 millimeters to 12 millimeters in diameter are in the case of the smaller individuals colorless and transparent and in that of the larger milky white. They are rhombohedral in habit, but one type being noted.

In the rhombohedral zone the dominant form is the positive rhombohedron p. ($10\bar{1}1$) developed as a series of dull planes. The negative rhombohedron δ. ($01\bar{1}2$) is present in considerable development, the planes being somewhat rounded and striated in the zone [$10\bar{1}1.11\bar{2}0$]. The positive rhombohedron m. ($40\bar{4}1$) is present in very small development but yielding good reflections. A vicinal rounding was noted between the planes of s. ($13.0.\bar{13}.1$) and b ($10\bar{1}0$) the latter of which is often ill defined, the form being mainly identified by its position in the prismatic zone. On one crystal a single plane of the negative rhombohedron η. ($04\bar{4}5$) was noted; the occurrence of the form must, however, be classed as doubtful. In the prismatic zone the persistent and symmetric occurrence of a series of planes between b ($10\bar{1}0$) and a ($11\bar{2}0$) was noted, the measurements corresponding fairly closely to the dihexagonal prism ς ($31\bar{4}0$). The form, however, is in no case very well defined and must be regarded as doubtful.

The positive scalenohedron N: ($53\bar{8}2$) in the zone [$10\bar{1}1.11\bar{2}0$] is present as a series of narrow bright planes considerably rounded in zone. This vicinal rounding interfered somewhat with the determination of the form although its presence is beyond question.

A decided twinning parallel to δ. ($01\bar{1}2$) is characteristic of these crystals as shown in figure 2.

SUMMARY OF MEASURED AND CALCULATED ANGLES

	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
δ.′ᵛ : m.	$10\bar{1}\bar{2}$: $40\bar{4}1$	4	77	54	77	58
δ.′ᵛ : s.	$10\bar{1}\bar{2}$: 13.0.13.1	4	68	20½	68	12½
δ. : η.	$01\bar{1}2$: $04\bar{4}5$	1	11	46	12	2
a : ς	$11\bar{2}0$: $31\bar{4}0$	9	15	44	16	6
N: : N:′	$53\bar{8}2$: $\bar{5}8\bar{3}2$	1	72	24	72	54½
N: : N:ᵛ	$53\bar{8}2$: $8\bar{3}\bar{5}2$	1	41	48	41	46
a: : N:	$11\bar{2}0$: $53\bar{8}2$	10	18	6	18	4

SARATOGA, SARATOGA CO.

Plate 17, figures 3, 4

Crystallized calcite was obtained from a limestone quarry operated by W. H. Gailor and situated $\frac{1}{2}$ mile north of Saratoga Springs. The calcite here occurs in irregular veins and cavities in a silicious, dolomitic limestone of Beekmantown formation, associated with dolomite and quartz in well developed crystals. The calcite crystals range in size from 3 to 25 millimeters in diameter. They are essentially of two crystallographic types genetically coincident with the dolomite and quartz. The genetic interrelation of the two types is not well defined although the crystals of type II appear to mark a somewhat later stage of deposition than those of type I.

Type I [fig. 3]. The crystals of this type are rhombohedral-pyramidal in habit, the dominant form in both combinations being the fundamental rhombohedron p. $(10\bar{1}1)$, present as a series of rough and dull planes yielding very poor reflections. The faces in the rhombohedral zone, other than p., are sharp and well defined, specially those of the prism b $(10\bar{1}0)$ which were used as reference points in this zone. The positive rhombohedron m. $(40\bar{4}1)$ and the negative rhombohedrons δ. $(01\bar{1}2)$ and φ. $(02\bar{2}1)$ are present, the latter as a series of sharp, brilliant but very narrow faces.

The zone of the second order pyramids $[0001.11\bar{2}0]$ is considerably developed in the combination shown in figure 3 and is characterized by a vicinal rounding of the pyramidal edges similar to that frequently noted in connection with the zone $[10\bar{1}1.11\bar{2}0]$. The bright points in this zone correspond to the second order pyramids α $(44\bar{8}3)$ and γ $(8.8.\overline{16}.3)$. The zonal relations aided in the identifying of these two forms; the polar edges of α are truncated by φ. $(02\bar{2}1)$ in the negative sextants and those of γ are truncated by m. in the positive sextants, the reflections in both instances falling well in zone.

The rare positive scalenohedron χ: $(29.17.\overline{46}.12)$ in the zone $[10\bar{1}1.11\bar{2}0]$

found by Schnorr on calcite from Neumark[1] is present in small development. On one crystal of the habit shown in figure 3 small modifying planes of the scalenohedron K: $(21\bar{3}1)$ were noted; the form is not repeated on any of the other crystals studied.

Type II [fig. 4]. Crystals of type II were noted on one specimen, superposed upon a layer of dolomite which latter mineral was assumed to be of the same generation as the calcite of type I. They are simpler in habit than those of the preceding type, the dominant forms being the rhombohedron δ. $(01\bar{1}2)$ and the prism b $(10\bar{1}0)$ both developed as smooth bright planes. In the zone $[10\bar{1}1.11\bar{2}0]$ the planes of χ: $(29.17.\overline{46}.12)$ and a $(11\bar{2}0)$ are quite rough and poorly defined.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
b : m.	$10\bar{1}0 : 40\bar{4}1$	3	13	48	14	13
φ. : m.	$02\bar{2}1 : 40\bar{4}1$	1	57	4	57	5
b : δ.	$10\bar{1}0 : 10\bar{1}2$	2	63	36½	63	45
b : $\varphi.'''$	$10\bar{1}0 : 20\bar{2}\bar{1}$	5	26	50	26	53
a : α	$11\bar{2}0 : 44\bar{8}3$	6	23	25	23	42
φ. : α	$02\bar{2}1 : 44\bar{8}3$	2	27	7½	27	15
a : γ	$11\bar{2}0 : 8.8.\overline{16}.3$	6	12	41	12	23
K: : φ.	$21\bar{3}1 : 02\bar{2}1$	2	37	38½	37	41
K: : $K:^{v}$	$21\bar{3}1 : 3\bar{1}\bar{2}1$	1	35	34	35	36
χ: : $\chi:^{v}$	$29.17.\overline{46}.12 : 46{:}\overline{17}.\overline{29}.12$	3	41	9	40	57
a : χ:	$11\bar{2}0 : 29.17.\overline{46}.12$	6	18	38	18	49

FAYETTEVILLE, ONONDAGA CO.

Plate 17, figures 5, 6

Calcite crystals occur on three specimens from the collection of the late John Gebhard jr, in the New York State Museum, which are labeled from Lafayetteville and were evidently collected at Fayetteville. The calcite occurs in thin veins and pockets in Niagara limestone, in most instances nearly filling the space left by the inclosing walls. The crystals are

[1] Schnorr. Wissensch. Beil. z. Programm d. Realgym. z. Zwickau. 1896. p. 16.

colorless, transparent or semitransparent and average 15 millimeters in vertical length; they are attached and in no instance was a doubly terminated individual observed.

The crystals are scalenohedral in habit, the dominant form being the positive scalenohedron K: $(21\bar{3}1)$. The combination shown in figure 5 is found on two of the three specimens and characterizes the calcite which lines the walls of pockets or vugs. In this combination the fundamental rhombohedron p. $(10\bar{1}1)$ is developed to a considerable habit, and the combination is marked by the absence of the modifying forms common to that shown in figure 6.

The combination shown in figure 6 is more scalenohedral than the preceding habit and shows a notable development of the positive rhombohedron m. $(40\bar{4}1)$ as well as in some instances of the prism a $(11\bar{2}0)$. The acute polar edges of K: are beveled by extremely narrow planes of the negative scalenohedron 𝔅: $(2.9.\bar{1}\bar{1}.5)$. Small, roughened planes of the second order pyramids γ $(8.8.\bar{1}\bar{6}.3)$ were present on all the crystals measured, the polar edges of this latter form being beveled in the negative sextant by a negative scalenohedron. This latter form could not be well established owing to the imperfect character of the reflections but from two fairly consistent measurements of the edge the indexes $(4.10.\bar{1}\bar{4}.3)$ are suggested for it as the nearest hypothetic scalenohedron of rational intercepts; the form must be considered as doubtful.

The forms present are a $(11\bar{2}0)$, γ $(8.8.\bar{1}\bar{6}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, K: $(21\bar{3}1)$ and 𝔅: $(2.9.\bar{1}\bar{1}.5)$.

UNION SPRINGS, CAYUGA CO.

Plates 18–20

The calcite from this locality was first described by Penfield and Ford[1] in 1900 from material furnished by Dr John M. Clarke, then State Paleontologist, and was further studied in a subsequent note by the writer.[2]

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[1] Penfield, S. L. & Ford, W. E. Am. Jour. Sci. 1900. 10:237-41.

[2] Whitlock, H. P. N. Y. State Mus. Bul. 98, 1905. p. 10.

The calcite crystals under consideration occur in vein material in the Onondaga limestone associated with saddle-shaped aggregates of dolomite and more rarely with crystallized quartz. They represent two generations, separated by a period in which dolomite was deposited, of which the older consists of brilliant individuals of extremely varied habit which are for the most part small, varying from 3 to 10 millimeters in length. One type of these crystals of the first generation is represented in figure 1, of the article by Penfield and Ford, above cited.

The crystals of the second or younger generation are generally larger in size than those of older deposition and are largely of scalenohedral type, showing a marked tendency to twinning according to several laws. They are frequently of a dull surface and black or dark gray in color as the result of bituminous inclusions. It is these latter which have been described at length by Penfield and Ford.

The small brilliant crystals of the first generation contain frequent inclusions of pyrite, chalcopyrite and marcasite in microscopic individuals, the latter mineral in beautiful doubly terminated twin crystals, specially prevalent in forms of the rhombohedral type. Frequent zones of deposition of these inclusions occur which render their aspect almost that of a phantom within the crystal.

First generation

Type I [pl. 18, fig. 1] Crystals of this type which occur in the lining of a thin seam are characterized by the second order pyramid γ $(8.8.\overline{16}.3)$ developed to a considerable habit. This pyramid is terminated by the rhombohedrons p. $(10\overline{1}1)$ and δ. $(01\overline{1}2)$ all of which forms give excellent reflections. The basal edges of the pyramid are in some instances truncated by narrow planes of the prism a $(11\overline{2}0)$, the type gradually merging into the combination of type II shown in figure 2. The crystals, which are for the most part colorless, transparent and brilliant, are very small, the largest not exceeding 4 millimeters in length.

Type II [pl. 18, fig. 2–4]. Crystals of type II are larger than those of the preceding type, averaging 10 millimeters in vertical length. They

are pyramidal-scalenohedral in habit. The combination shown in figure 2 is essentially the same as that figured by Penfield and Ford in figure 1 of their paper. This combination is characterized by the pyramid γ $(8.8.\overline{16}.3)$ and the positive scalenohedrons K: $(21\bar{3}1)$ and M: $(7.4.\overline{11}.3)$ developed to the extent of dominant forms. The prisms b $(10\bar{1}0)$ and a $(11\bar{2}0)$ are present as relatively small planes. The polar edges of γ are truncated in the positive sextants by narrow, brilliant planes of m. $(40\bar{4}1)$, and the polar edges of M: are beveled in the negative sextants by narrow, somewhat roughened planes of the negative scalenohedron Θ $(12\bar{3}1)$. The two beveling planes of this latter form were apparently assumed by Penfield and Ford to correspond to the single plane of the rhombohedron $(0.12.\overline{12}.5)$ from which, however, they were unable to obtain satisfactory reflections.

The combination shown in figure 3 differs mainly from the preceding habit in the absence of the scalenohedron M: and in the presence of the rhombohedrons p. $(10\bar{1}1)$ and δ. $(01\bar{1}2)$ in termination. A small but distinct plane of the positive rhombohedron s. $(13.0.\overline{13}.1)$ was noted on one crystal.

In the combination shown in figure 4 the scalenohedron M: is present as a dominant form and K: is reduced to a series of small faces modifying the termination between M: and p. The polar edges of K: are here truncated in the negative sextants by narrow bright planes of the negative rhombohedron φ. $(02\bar{2}1)$.

Type III [pl. 18, fig. 5, 6]. Crystals of this type occur in a loosely compacted mass deposited on a layer of crypto-crystalline carbonate of lime occupying the space between the crystallized calcite and the limestone wall of the cavity or vug to the depth of about 5 millimeters. The calcite crystals are piled upon this crystalline layer to the depth of from 10 to 15 millimeters, the largest individuals lying in the top layers. The order and manner of deposition suggest the possible derivation from a solution which originally completely filled the space and deposited its dissolved carbonate of lime first from a rapidly then from a slowly crystallizing medium. The

crystals of this type which are remarkably clear, brilliant and well developed, range in size from 5 to 20 millimeters in diameter. All the faces give excellent reflections. The middle edges of the rhombohedron p. $(10\bar{1}1)$ are beveled by the scalenohedron K: $(21\bar{3}1)$. The combination shown in figure 5 is characterized by the presence of the positive scalenohedron c: $(61\bar{7}8)$ in the zone $[10\bar{1}1.01\bar{1}2]$. The prism a $(11\bar{2}0)$ is present as a small face in this zone. In the zone of the pyramidal faces $[16.\bar{8}.\bar{8}.3.8.8.\overline{16}.3]$ occur the forms m. $(40\bar{4}1)$ and $\mathfrak{Y}$: $(19.10.\overline{29}.6)$ both lying well within the zone and agreeing as to measured angles well within the limits of accuracy.

Second generation

Type IV [pl. 18, fig. 7]. The crystals of this type which are prismatic in habit are considerably larger than those generally noted from this locality, individuals 30 millimeters in length being not uncommon. Inclusions of marcasite in microscopic crystals are so plentiful as to render the calcite, which would otherwise be transparent, quite translucent. These inclusions are distributed along planes parallel to the rhombohedron p. $(10\bar{1}1)$. The planes of a $(11\bar{2}0)$ and γ $(8.8.\overline{16}.3)$ are both sharp and brilliant as are, to a somewhat less degree, those of b $(10\bar{1}0)$. A new negative scalenohedron is present in relatively small development. The measured angles of this form conform closely to those calculated for the indexes $(3.15.\overline{18}.2)$ which give the Naumann symbol $-6R\frac{3}{2}$. This scalenohedron to which the letter $\mathfrak{x}$ has been assigned falls close to $(3.16.\overline{19}.2) = \frac{13}{2}R\frac{19}{13}$ described by Melczer[1] on the calcite from Budapest, and in the former paper cited on page 105 was assumed to be the latter form. The negative rhombohedron δ. $(01\bar{1}2)$ is here present as a dominant form developed as a series of smooth dull planes.

Type V [pl. 19, fig. 1–4]. The crystals of this type have been amply described by Penfield and Ford as above cited. They differ essentially from all previously described in size, color and in their strong twinning tendency. In many instances single crystals of this type attain a length

[1] Melczer, G. Földtani Közlöng 1896, 26:79.

of 50 millimeters measured on the composition plane. The faces are dull and the crystals are black or dark gray in color as the result of bituminous inclusions. In general habit they are similar to those described under type II, the following forms being noted:—M: $(7.4.\bar{1}\bar{1}.3)$, γ $(8.8.\bar{1}\bar{6}.3)$ and b $(10\bar{1}0)$, the latter only occasionally present.

Twin crystals of this type, according to three of the four laws known to calcite, are very common, viz:

Parallel to the basal plane o (0001)
Parallel to the rhombohedron δ. $(01\bar{1}2)$
Parallel to the rhombohedron φ. $(02\bar{2}1)$

The latter of these laws is rare for calcite. Figure 1 shows an untwinned scalenohedral crystal on which the position of the three twinning planes is indicated. Figures 2, 3 and 4 show crystals of type V twinned according to the above laws.[1] The twin crystal habits shown in figures 3 and 4 are invariably distorted to the extension of one set of axially opposite scalenohedral planes; this distortion operates in the case of the crystals twinned parallel to φ. [fig. 4] to the suppression of the reentrant angles ordinarily characteristic of twinning.

Type VI [pl. 19, fig. 5, 6]. This type is found in crystals of the second generation which occur deposited on a thin layer of first generation calcite of rhombohedral habit (type III). They differ from all which have been previously described in two essential characteristics: they are opaque and milky white in color and show a complete absence of all marcasite or pyrite inclusions. The crystals are scalenohedral in habit, having for dominant forms the scalenohedrons M: $(7.4.\bar{1}\bar{1}.3)$ and 𝔜: $(19.10.\bar{2}\bar{9}.6)$. The latter form which is in the zone $[40\bar{4}1.8.8.\bar{1}\bar{6}.3]$ is also present on crystals of type III. The rhombohedrons p. $(10\bar{1}1)$, m. $(40\bar{4}1)$ and δ. $(01\bar{1}2)$ and the

[1] In figures 3 and 4 the writer has followed the excellent method inaugurated by Messrs Penfield and Ford, of projecting the twin crystal with its twinning plane vertical and parallel to a hypothetical plane $12\bar{1}0$ of the ordinary projection.

pyramid γ $(8.8.\overline{16}.3)$ are present in relatively small development. Twinning parallel to the basal plane o (0001) is fairly common [fig. 6].

Type VII [pl. 19, fig. 7]. Rhombohedral crystals of this type occur on several specimens in milky white individuals of about 20 millimeters diameter. They are frequently twinned parallel to the basal plane o (0001) and suggest in their development those described under Rossie, Sterlingbush and Crown Point. The forms noted are:

o (0001), a $(11\bar{2}0)$, m. $(40\bar{4}1)$, p. $(10\bar{1}1)$ and δ. $(01\bar{1}2)$.

The zonal relations of the forms occurring on the seven types are shown on the stereographic projection, plate 20.

SUMMARY OF DISTRIBUTION OF FORMS

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	FIRST GENERATION			SECOND GENERATION			
			TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	TYPE VI	TYPE VII
o	oP	0001	....	....	....	....	....	....	x
a	$\infty P2$	$11\bar{2}0$	x	x	x	x	....	....	x
b	∞R	$10\bar{1}0$	....	x	....	x	x	....	....
γ	$\frac{16}{3}P2$	$8.8.\overline{16}.3$	x	x	....	x	x	x	....
s.	13R	$13.0.\overline{13}.1$	....	x	....	....	....	....	....
m.	4R	$40\bar{4}1$	....	x	x	....	....	x	x
p.	R	$10\bar{1}1$	x	x	x	....	....	x	x
δ.	$-\frac{1}{2}R$	$01\bar{1}2$	x	x	....	x	....	x	x
φ.	$-2R$	$02\bar{2}1$	....	x	....	....	....	....	....
c:	$+\frac{5}{8}R\frac{7}{5}$	$61\bar{7}8$	....	....	x	....	....	....	....
K:	$+R3$	$21\bar{3}1$	....	x	x	....	....	....	....
M:	$+R\frac{11}{3}$	$7.4.\overline{11}.3$	....	x	....	....	x	x	....
𝔜:	$+\frac{3}{2}R\frac{29}{9}$	$19.10.\overline{29}.6$	....	....	x	....	....	x	....
Θ	$-R3$	$12\bar{3}1$	....	x	....	....	....	....	....
𝔯	$-6R\frac{3}{2}$	$3.15.\overline{18}.2$	....	....	....	x	....	....	....

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
a : γ	$11\bar{2}0 : 8.8.\overline{16}.3$	11	12	12	12	23
m. . γ	$40\bar{4}1 : 8.8.\overline{16}.3$	6	29	13	29	14
p. : s.	$10\bar{1}1 : 13.0.\overline{13}.1$	2	41	8	40	56
p. : m.	$10\bar{1}1 : 40\bar{4}1$	4	31	12½	31	10½
m. : m.	$40\bar{4}1 : \bar{4}401$	2	114	14	114	10
p. : δ.	$10\bar{1}1 : 01\bar{1}2$	2	70	48½	70	51½
p. : φ.	$10\bar{1}1 : 02\bar{2}1$	1	107	50	107	43½
p. : c.	$10\bar{1}1 : 61\bar{7}8$	5	7	37	7	43½
K: : K:	$21\bar{3}1 : \bar{2}3\bar{1}1$	5	75	24	75	22
K: : K:	$21\bar{3}1 : 3\bar{1}\bar{2}1$	4	35	41	35	36
M: : M:	$7.4.\overline{11}.3 : \bar{7}.11.\bar{4}.3$	2	73	54½	73	40
M: : M:	$7.4.\overline{11}.3 : 11.\bar{4}.\bar{7}.3$	1	40	1	40	4
M: : M:	$7.4.\overline{11}.3 : 4.7.\overline{11}.\bar{3}$	3	39	3	39	11
m. : $\mathfrak{Y}$:	$40\bar{4}1 : 19.10.\overline{29}.6$	8	19	21½	19	17
$\mathfrak{Y}$: : $\mathfrak{Y}$:	$19.10.\overline{29}.6 : \overline{19}.29.\overline{10}.6$	1	77	7	77	44
a : $\mathfrak{Y}$:	$11\bar{2}0 : 19.10.\overline{29}.6$	2	16	36½	16	44
Θ : Θ	$12\bar{3}1 : 3\bar{2}\bar{1}1$	1	75	34	75	22
Θ : Θ	$12\bar{3}1 : \bar{1}3\bar{2}1$	4	35	55	35	36
$\mathfrak{r}$: $\mathfrak{r}$	$3.15.\overline{18}.2 : 18.\overline{15}.\bar{3}.2$	2	101	40	101	4½
$\mathfrak{r}$: $\mathfrak{r}$	$3.15.\overline{18}.2 : 3.18.\overline{15}.2$	6	17	36	17	46
a : $\mathfrak{r}$	$11\bar{2}0 : 3.15.\overline{18}.2$	6	21	54	22	7

HOWES CAVE, SCHOHARIE CO.

Plates 21, 22

Calcite occurs at Howes Cave in brilliant transparent crystals filling or partly filling the veins in the Rondout limestone. The specimens which form the basis for the following notes were collected through the courtesy of the Helderberg Cement Co., from the mine in the Rondout limestone which formerly furnished natural cement rock to this company. The crystals which vary in size from 60 millimeters in diameter to microscopic individuals are of more or less uniform habit and are invariably characterized by a marked twinning parallel to δ. ($01\bar{1}2$). They are frequently associated with tufted aggregates of acicular aragonite which appears, in one instance at least, to have been derived from the re-solution of the calcite. In the instance noted a geodic mass almost completely filled with crystallized calcite yielded on fracture several fine tufts of arago-

nite deposited on calcite crystals of the prevailing habit which latter were found to be deeply pitted with natural etchings.

Type I [pl. 21, fig. 1]. Small crystals of this habit were noted on one specimen occurring in a thin layer partly covered by the larger individuals of type II to which they stand in close crystallographic relation. They evidently mark an earlier generation of calcite deposition than these latter. In habit they are quite steeply scalenohedral, the dominant forms being K: (21$\bar{3}$1) and $\mathfrak{J}$: (62$\bar{8}$1). The polar edges of $\mathfrak{J}$: are truncated in the positive sextants by narrow planes of the positive rhombohedron q. (70$\bar{7}$1). The combination is terminated by the negative rhombohedron δ. (01$\bar{1}$2). The positive rhombohedron p. (10$\bar{1}$1) is occasionally present as a series of minute planes.

Type II [pl. 21, fig. 2–5]. Crystals of this type which are by far the most common to the occurrence are characterized by considerable complexity as well as by a strong twinning tendency which latter finds expression in nearly all of the crystals studied.

The crystals are scalenohedral in habit with a somewhat rhombohedral aspect due to the dominance of the scalenohedron b: (71$\bar{8}$9) which lies very close to the fundamental rhombohedron. In the rhombohedral zone the rhombohedron p. (10$\bar{1}$1) is frequently present alternating with the low scalenohedron b: (71$\bar{8}$9) which latter, although clearly defined, is without question a built-up form more or less vicinal in character. The planes of p. are smooth but rather dull. The rhombohedrons m. (40$\bar{4}$1) and q. (70$\bar{7}$1) occur as narrow but extremely brilliant faces, giving excellent reflections and beveling the edges of U: (10.4.$\overline{14}$.3) and $\mathfrak{J}$: (62$\bar{8}$1) respectively. Small brilliant planes of the prism b (10$\bar{1}$0) are present and the negative rhombohedron Φ. (0.14.$\overline{14}$.1) was noted in relatively small development on several crystals.

The rhombohedron δ. (01$\bar{1}$2) is universally present as brilliant faces which make excellent points of reference in this zone.

The scalenohedron K: (21$\bar{3}$1) which is a dominant form of type I is present as a series of brilliant, well defined planes. The scalenohedrons U: (10.4.$\overline{14}$.3) and $\mathfrak{J}$: (62$\bar{8}$1) are universally present. A new positive scale-

nohedron, having the indexes $(9.4.\overline{13}.2)$ was noted in most of the crystals measured. This scalenohedron, to which the letter $\mathfrak{H}$ has been assigned is present in best development on the combination shown in figure 2. A more complex combination which is shown in figure 3 yielded in addition to the above forms the positive scalenohedron $\mathfrak{K}$: $(8.4.\overline{12}.1)$ in the zone $[40\bar{4}1.11\bar{2}0]$, present as a series of bright well developed faces, and the positive scalenohedron T $(42\bar{6}1)$. The latter form which was noted on but one crystal was mainly identified by zonal relations. On one crystal presenting the combination shown in figure 4 two faces of the negative scalenohedron $\mathfrak{p}$: $(13\bar{4}1)$ were noted; the form, however, was not repeated in any of the crystals subsequently measured. A negative scalenohedron having indexes closely approaching $(6.21.\overline{27}.5)$ was found repeatedly throughout the type. The planes of this form although bright are somewhat rounded giving poor reflections of the goniometer signal, and no consistent readings could be obtained. The form must therefore be classed as doubtful.

A very marked tendency toward twinning parallel to the plane δ. $(01\bar{1}2)$ results in the production of thin flat extensions of one individual of the pair and the formation of a deep reentering angle as shown in figure 5. So common is this form of twinning that it is rarely absent from crystals of this occurrence to which it gives a distinct character. Twinning according to this law is common in calcite crystals and examples of it may be found in almost every important occurrence. The abnormal extension of one member of the twin above noted is, however, unique and seems to indicate a metagenic rather than a paragenic mode of twinning.

Type III [pl. 21, fig. 6.] Small calcite crystals of this type occur lining the fossil remains of R h y n c h o n e l l a w i l s o n i which thickly stud portions of the Helderbergian limestone, overlying the Rondout. The crystals though small are remarkably brilliant and give excellent reflections in all zones. Of the observed forms, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, p. $(10\bar{1}1)$ and K: $(21\bar{3}1)$ are common to the crystals previously described from the underlying beds of the Rondout limestone. The scalenohedrons are all of the zone $[01\bar{1}2.10\bar{1}1]$. The scalenohedron e: $(41\bar{5}6)$ here replaces

b: of the principal type. This form appears as a series of well developed planes having none of the vicinal characters which mark the development of b: of the principal type. The scalenohedron H: $(31\bar{4}2)$ occurs as a series of narrow faces between K: and p. Traces of the characteristic twinning which mark the crystals of the principal type are here noted; the twinning tendency is, however, very weak and only finds expression in an occasional shallow reentering "gash."

The interesting zonal relations of the occurring forms are shown in the stereographic projection [plate 22].

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
∂. : m.	$10\bar{1}\bar{2} : 40\bar{4}1$	3	77	58½	77	58
∂. : q.	$10\bar{1}\bar{2} : 70\bar{7}1$	2	72	9	72	$\bar{4}$
∂. : b	$10\bar{1}\bar{2} : 10\bar{1}0$	2	64	12	63	45
∂. : Φ.	$01\bar{1}2 : 0.14.\overline{14}.1$	1	59	46	59	36
e: : e:	$41\bar{5}6 : \bar{4}5\bar{1}6$	1	54	9	54	7
e: : e:	$41\bar{5}6 : 5\bar{1}\bar{4}6$	1	13	12	13	3½
b: : b:	$71\bar{8}9 : \bar{7}8\bar{1}9$	1	61	34	61	35
b: : b:	$71\bar{8}9 : 8\bar{1}\bar{7}9$	2	8	32	8	23
b: : b:	$71\bar{8}9 : \bar{1}789$	1	71	34	71	37
H: : K:	$31\bar{4}2 : 21\bar{3}1$	3	9	22	9	37
K: : K:	$21\bar{3}1 : \bar{2}3\bar{1}1$	2	75	17	75	22
K: : K:	$21\bar{3}1 : 3\bar{1}\bar{2}1$	1	35	42	35	36
K: : K:	$21\bar{3}1 : 12\bar{3}\bar{1}$	1	46	57	47	1½
$\mathfrak{p}$: : $\mathfrak{p}$:	$13\bar{4}1 : \bar{1}4\bar{3}1$	1	26	51	26	44½
U: : U:	$10.4.\overline{14}.3 : 14.\bar{4}.\overline{10}.3$	2	31	13	31	16
U: : U:	$10.4.\overline{14}.3 : 4.10.\overline{14}.\bar{3}$	1	38	35	38	49
T : T	$42\bar{6}1 : 6\bar{2}\bar{4}1$	1	38	17	37	30
T : $\mathfrak{J}$:	$42\bar{6}1 : 62\bar{8}1$	2	6	23	5	54
$\mathfrak{H}$: $\mathfrak{H}$	$9.4.\overline{13}.2 : 13.\bar{4}.\bar{9}.2$	3	34	20	34	25
$\mathfrak{H}$: $\mathfrak{H}$	$9.4.\overline{13}.2 : 4.9.\overline{13}.\bar{2}$	1	31	42	31	55
$\mathfrak{H}$: $\mathfrak{K}$	$9.4.\overline{13}.2 : 8.4.\overline{12}.1$	1	4	43	4	47
$\mathfrak{H}$: $\mathfrak{J}$:	$9.4.\overline{13}.2 : 62\bar{8}1$	3	3	59	4	6
$\mathfrak{J}$: : q.	$62\bar{8}1 : 70\bar{7}1$	6	13	46½	13	45½
$\mathfrak{J}$: : $\mathfrak{J}$:	$62\bar{8}1 : 26\bar{8}\bar{1}$	1	35	53	35	52
$\mathfrak{J}$: : m.	$62\bar{8}1 : 40\bar{4}1$	2	15	8	14	59
$\mathfrak{K}$: : $\mathfrak{K}$:	$8.4.\overline{12}.1 : 12.\bar{4}.\bar{8}.1$	2	37	57½	38	2
$\mathfrak{K}$: : m.	$8.4.\overline{12}.1 : 40\bar{4}1$	2	20	43	20	44½

SOUTH BETHLEHEM, ALBANY CO.

Plate 23, figures 1–4

Crystallized calcite occurs in veins and pockets in Cobleskill limestone at the road metal quarry of the Callanan Road Improvement Co. at South Bethlehem. The calcite crystals, which vary in size from 25 millimeters in diameter to semimicroscopic individuals are associated with crystallized barite and with occasional needlelike tufts of aragonite, the latter mineral being evidently of a later generation. The barite is, for the most part, associated with the calcite crystals of type I and is undoubtedly representative of the same stage of crystal genesis.

Type I [fig. 1, 2]. The crystals of this type, which are notably larger than those of types II and III, are translucent and milky white in color. They contain frequent inclusions of graphite in thin plates erratically disposed throughout the crystals and bearing no relation to the crystallographic symmetry. The crystals are rhombohedral in habit having for the dominant planes the rhombohedrons p. $(10\bar{1}1)$ and e $(01\bar{1}2)$. The combination shown in figure 1, which represents some of the larger individuals is characterized by dominant planes of p. deeply pitted by natural etchings. The positive rhombohedrons m. $(40\bar{4}1)$ and q. $(70\bar{7}1)$ are present, the former as a series of small bright planes and the latter as a somewhat indefinite series of dull, rounded planes beveling the polar edges of ℨ: $(62\bar{8}1)$ in the positive sextants and identified chiefly by its presence in this zone. The positive scalenohedrons K: $(21\bar{3}1)$ and ℨ: $(62\bar{8}1)$ are present, the latter in considerable development. The combination shown in figure 2 differs from the above chiefly in the more considerable development of e. $(01\bar{1}2)$ and in the presence of the positive rhombohedron s. $(13.0.\overline{13}.1)$ which here replaces q. to the extent of a considerable development. The faces of s. are rounded and ill defined owing to the presence of vicinal forms. In one instance a crystal of the combination shown in figure 1 was noted twinned parallel to the basal plane o (0001).

Type II [fig. 3]. Crystals of this type which are colorless, transparent and average 3 millimeters in diameter are characterized by the presence

of forms in the zone $[1102.10\bar{1}1.11\bar{2}0]$. In this zone are present the following forms δ. $(01\bar{1}2)$, x: $(4.3.\bar{7}.10)$, p. $(10\bar{1}1)$, G: $(72\bar{9}5)$ and K: $(21\bar{3}1)$. The polar termination consisting of the planes of δ. and x: is much rounded and striated by vicinal planes and the faces of the scalenohedron though well defined are dull. The positive rhombohedron m. $(40\bar{4}1)$ and the positive scalenohedron $\mathfrak{J}$: are present in small development.

Type III [fig. 4]. Minute crystals of this type were noted in one specimen. They form a thin druse deposited directly upon the surface of the limestone. They differ chiefly in habit from the preceding types in the dominance of the scalenohedron x: $(4.3.\bar{7}.10)$ and in the presence of the negative rhombohedrons η. $(04\bar{4}5)$ and θ. $(07\bar{7}8)$, both of which latter forms are represented by planes of fine brilliancy. The prominent planes of the prism b $(10\bar{1}0)$ are rounded and uneven. The faces of the zone $[1102.10\bar{1}1.11\bar{2}0]$ which here consists of forms δ. $(01\bar{1}2)$, x: $(4.3.\bar{7}.10)$, p. $10\bar{1}1)$ and K: $(21\bar{3}1)$ are considerably striated, particularly in the larger of the crystals which measure 2 millimeters in diameter. The general aspect of the combination of this type is low scalenohedral.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
δ. : s.	$\bar{1}012 : 13.0.\bar{13}.1$	1	111	41	111	47½
p. : m.	$10\bar{1}1 : 40\bar{4}1$	3	31	17½	31	10½
m. : m.	$40\bar{4}1 : 044\bar{1}$	1	65	40	65	50
δ. : p.	$\bar{1}012 : 10\bar{1}1$	5	70	48½	70	51½
δ. : b	$01\bar{1}2 : 01\bar{1}0$	5	63	24	63	45
δ. : η.	$01\bar{1}2 : 04\bar{4}5$	5	12	4	12	1¾
δ. : θ.	$01\bar{1}2 : 07\bar{7}8$	4	14	46¾	14	33
δ. : x:	$01\bar{1}2 : 4.3.\bar{7}.10$	8	16	58½	17	2
x: : x:	$4.3.\bar{7}.10 : 7.\bar{3}.\bar{4}.10$	3	25	32½	25	23½
p. : G:	$10\bar{1}\bar{1} : 72\bar{9}5$	6	16	25½	16	36
K: : K:	$21\bar{3}1 : \bar{2}3\bar{1}1$	3	75	18	75	22
K: : K:	$21\bar{3}1 : 3\bar{1}\bar{2}1$	3	36	5	35	36
m. : K:	$21\bar{3}1 : 40\bar{4}1$	4	19	32½	19	24
$\mathfrak{J}$: : $\mathfrak{J}$:	$62\bar{8}1 : \bar{6}8\bar{2}1$	4	91	2	91	3
$\mathfrak{J}$: : $\mathfrak{J}$:	$62\bar{8}1 : 8\bar{2}\bar{6}1$	2	27	25½	27	31

NEW BALTIMORE, GREENE CO.

Plate 23, figures 5, 6

Crystallized calcite from the quarry of A. C. Driscoll located at New Baltimore was obtained through the kindness of Mr H. S. Peck by whom it was collected in 1901 and who furnished several specimens for study.

The crystals which measure in some instances 60 millimeters in diameter, are translucent and milky white in color. They represent two generations of crystal formation well defined and, from the simplicity of the combinations involved, easily interpreted. Calcite of the first generation is crystallized in unmodified primary rhombohedrons p. $(10\bar{1}1)$, the individuals averaging 15 millimeters in diameter. The crystals which represent the second generation of calcite are shown in figure 5. They are rhombohedral-scalenohedral in habit and present a combination of the negative rhombohedron $\delta.(01\bar{1}2)$ with the scalenohedron $K:(21\bar{3}1)$, the forms being present in about equal developments. Included graphite in thin plates forms phantom crystals outlining the primitive rhombohedron of the first generation and in some instances imparting a dark gray color to this combination. On several specimens the superposition of the two generations shown in figure 6 was noted. In these instances the growth of the elements of the second generation are clearly defined by the graphite inclusions, entirely absent in the rhombohedron of the first generation.

CATSKILL, GREENE CO.

Plate 24, figures 1–5

The types of calcite crystals from several localities in the vicinity of Catskill present such similarity of habit that it has been deemed advisable to here group them in order that they may be compared somewhat in detail. The writer is indebted to Mr George H. Chadwick for an excellent study series of crystals from Austin's glen, $1\frac{1}{2}$ miles northwest of Catskill. Suites of calcite specimens were obtained for study from the quarry of the Alsen Cement Co., situated 6 miles south of Catskill and from the quarry of the Catskill Cement Co., situated at West Camp, about 7 miles south of Catskill.

The calcite occurs in seams in the Rondout limestone and is in some instances associated with crystallized quartz.

Type I [fig. 1, 2]. Crystals of this type are rhombohedral-scalenohedral in habit combining the negative rhombohedron δ. $(01\bar{1}2)$ with a steep positive scalenohedron. On the crystals from Austin's glen, which are all of this type, the measured angles of this scalenohedron corresponded to 𝔳 $(10.3.\bar{1}\bar{3}.2)$, a form first noted by Sansoni[1] on calcite from Freiberg The combination from Austin's glen is shown in figure 1.

A combination of striking similarity from Alsen is shown in figure 2. In this occurrence the dominant scalenohedron differs slightly from that of the Austin's glen combination, the measured angles corresponding closely to the theoretical values of a new positive scalenohedron in the zone $[40\bar{4}1.11\bar{2}0]$ having the indexes $(11.3.\bar{1}\bar{4}.2) = 4R\frac{7}{4}$. The letter 𝔑: has been assigned to this form. The prism b $(10\bar{1}0)$ is present in small development on the crystals of this type. In both combinations the planes of the dominant scalenohedron are well developed, sharp and quite bright and the difference in measured angles although small is constant and consistent, permitting no doubt as to the identity of the two forms in question.

Type II [fig. 3, 4]. The crystals of this type which are milky white in color are more rhombohedral in habit than those of type I. They also differ from these latter in the greater development of the prism b $(10\bar{1}0)$. A well developed series of forms in the zone $[10\bar{1}1.11\bar{2}0]$ characterize the combinations of this type. The combination shown in figure 3 which occurs at Alsen presents three positive scalenohedrons in this zone, viz: H: $(31\bar{4}2)$, N: $(53\bar{8}2)$ and P: $(32\bar{5}1)$ the last of which is only occasionally present in small development. The combination shown in figure 4 occurs at West Camp and is characteristic of that locality. The scalenohedron N: $(53\bar{8}2)$ of the Alsen combination is here present in somewhat greater development and the prism a $(11\bar{2}0)$, absent from the former combination, is represented by well developed planes.

As is common with forms in this zone, the planes of H:, N:, P: and a

[1] Sansoni, F. Jiorn. Min. 1894. 5:72.

are considerably striated parallel to the zone axis, producing multiple images of the goniometer signal and rendering the measurement of the interfacial angles somewhat difficult. The forms are, however, sufficiently rational and well established to admit of no doubt as to their true indexes.

Type III [fig. 5]. The crystals of this type which were noted only on the specimens from Alsen, are colorless, transparent and covered with a light, yellow, iridescent film probably due to iron. They are scalenohedral in habit, presenting three scalenohedrons of the zone [$1\bar{1}02.10\bar{1}1.11\bar{2}0$], viz: v: ($7.4.\overline{11}.15$), G: ($72\bar{9}5$) and P: ($32\bar{5}1$) the last of which is also occasionally present on the crystals of type II from this locality. The negative rhombohedron e. ($01\bar{1}2$), which is a dominant form on the crystals of types I and II, is here present in relatively small development. Small planes of the prism b ($10\bar{1}0$) are present on combinations of this type. As in the case of the crystals of type II the scalenohedral zone is much striated.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED °	MEASURED ′	CALCULATED °	CALCULATED ′
p. : v:	$10\bar{1}1 : 7.4.\overline{11}.15$	5	17	52½	17	47
p. : G:	$10\bar{1}1 : 72\bar{9}5$	8	16	15	16	36
p. : H:	$10\bar{1}1 : 31\bar{4}2$	3	19	41	19	25
p. : N:	$10\bar{1}1 : 53\bar{8}2$	6	34	41	34	28
N: : N:	$53\bar{8}2 : \bar{5}8\bar{3}2$	3	72	49	72	54
p. : P:	$10\bar{1}1 : 32\bar{5}1$	9	37	34	37	55
$\mathfrak{v}$: $\mathfrak{v}$	$10.3.\overline{13}.2 : \overline{10}.13.\bar{3}.2$	3	92	55	92	46
$\mathfrak{v}$: $\mathfrak{v}$	$10.3.\overline{13}.2 : 13.\bar{3}.\overline{10}.2$	7	25	3	25	5
$\mathfrak{v}$: $\mathfrak{v}$	$10.3.\overline{13}.2 : 3.10.\overline{13}.\bar{2}$	6	39	24	39	13
$\mathfrak{N}$: : $\mathfrak{N}$:	$11.3.\overline{14}.2 : \overline{11}.14.\bar{3}.2$	5	94	54	94	56
$\mathfrak{N}$: : $\mathfrak{N}$:	$11.3.\overline{14}.2 : 14.\bar{3}.\overline{11}.2$	8	22	41	23	11
$\mathfrak{N}$: : $\mathfrak{N}$:	$11.3.\overline{14}.2 : 3.11.\overline{14}.\bar{2}$	10	40	37¾	40	36

HUDSON, COLUMBIA CO.

Plate 24, figure 6

Small crystals of calcite occur in veins in the Becraft limestone of the Helderberg series at the Hudson City quarry situated a mile southeast of Hudson.

The crystals which average 5 millimeters in diameter are colorless and transparent. They are rhombohedral in habit, having for dominant form the fundamental rhombohedron p. $(10\bar{1}1)$. The rare scalenohedron $\mathfrak{M}$: $(16.4.\overline{20}.3)$ in the zone $[40\bar{4}1.11\bar{2}0]$ is present as a series of small bright planes giving good reflections. This scalenohedron which was first noted by Sachs[1] on the calcite from Tharandt lies close to the scalenohedrons $\mathfrak{v}$ $(10.3.\overline{13}.2)$ from Austin's glen and $\mathfrak{N}$: $(11.3.\overline{14}.2)$ from Alsen, the former of which forms also occurs on the calcite crystals from the Helderberg limestone at localities not widely separated from Hudson. The prism a $(11\bar{2}0)$ is present in relatively small development.

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
$\mathfrak{M}$: : $\mathfrak{M}$:	$16.4.\overline{20}.3 : \overline{16}.20.\bar{4}.3$	1	96	15	96	26½
$\mathfrak{M}$: : $\mathfrak{M}$:	$16.4.\overline{20}.3 : 20.\bar{4}.\overline{16}.3$	6	21	31	21	30
$\mathfrak{M}$: : $\mathfrak{M}$:	$16.4.\overline{20}.3 : 4.16.\overline{20}.\bar{3}$	3	42	24	42	27

RONDOUT, ULSTER CO.

Plates 25–27

The vein calcite of Rondout occurs, for the most part, as a secondary deposit on dolomite and presents types of crystallization of marked variety and unique development. The associated pyrite which is here present in extremely minute crystals, occurs in many cases included in the larger calcite individuals arranged along the crystallogenetic lines of the latter mineral in distinct bands on the surface of, or as phantoms within, the crystals of the calcite. These structure lines as outlined by the pyrite inclusions are of notable interest in their relation to the development of the calcite. Somewhat similar inclusions have been noted in the calcite from Phoenixville, Pa.

[1] Sachs, A. Zeitschr. f. Kryst. 1902. 36:449.

Type I [pl. 25, fig. 1]. Crystals of this type are simple combinations of the negative rhombohedron $\delta.\,(01\bar{1}2)$ and the prism $b\,(10\bar{1}0)$, the latter form being developed through a wide range of habit from a series of narrow triangular faces to a dominance which produces crystal individuals having a relative length of two or three times their diameter. The prismatic faces are invariably striated vertically.

Type II [pl. 25, fig. 2–6]. Crystals of this type are characterized by the presence of the steep positive scalenohedron $\mathfrak{D}\,(15.4.\overline{19}.3)$. In the combination shown in figure 2 the dominance of this scalenohedron produces long slender crystals, terminated by the negative rhombohedron $\delta.\,(01\bar{1}2)$. Crystals of this combination, which are of frequent occurrence, reach a maximum length of 25 millimeters. Inclusions of pyrite were noted in several instances, outlining the faces of a steep positive scalenohedron, possibly $\mathfrak{D}$. A more rhombohedral variation of this type is shown in figure 3 and was noted on a number of specimens. In this instance the prism $a\,(11\bar{2}0)$ is present truncating the middle edges of the scalenohedron $\mathfrak{D}$. The basal plane $o\,(0001)$ and the positive rhombohedron $m.\,(40\bar{4}1)$ are occasionally present in crystals of this habit. The combination shown in figure 4 is of more uncommon occurrence in crystals of this type than either of the two preceding habits. The crystals are characterized by the equal development of the rhombohedrons $\delta.\,(01\bar{1}2)$ and $\Delta.\,(07\bar{7}2)$, the scalenohedron $\mathfrak{D}$ being reduced to comparatively small development. The prism a is sometimes present in this combination. Twinning parallel to the basal plane o and the negative rhombohedron $\delta.$ is frequent with crystals of this type the resulting combinations being shown in figures 5 and 6.

Type III [pl. 26, fig. 1–3]. Crystals of type III are prismatic in habit and are chiefly characterized by the dominance of the prism $a\,(11\bar{2}0)$ and the negative rhombohedron $\delta.\,(01\bar{1}2)$. The combination shown in figure 1 which was noted on several specimens, presents in addition to the two forms characteristic of the type the positive scalenohedron $\mathfrak{D}\,(15.4.\overline{19}.3)$ of type II and the negative scalenohedron $\mathfrak{r}\,(3.15.\overline{18}.2)$. The latter form which was previously noted under Union Springs is present as a series of

well developed planes of fair brilliancy. The faces of the prism a are striated parallel to the middle edges of 𝔇. The combination shown in figure 2 which occurred on only one specimen differs from the preceding one in the indexes of the negative scalenohedron which in this case are $(3.16.\bar{19}.2) = \mathfrak{y}$. This scalenohedron was first noted by Melczer[1] on the calcite from Budapest. The prism a which in the preceding combination is deeply striated is represented in this combination by smooth planes of maximum brilliancy. The combination shown in figure 3 which was noted on one specimen differs from the two former in the absence of the scalenohedron 𝔇 as well as the negative scalenohedrons previously noted. The positive rhombohedron p. $(10\bar{1}1)$ and the scalenohedron K: $(21\bar{3}1)$ are present in relatively small development. The planes of the prism a are striated parallel to the zone $[10\bar{1}1.11\bar{2}0]$.

Type IV [pl. 26, fig. 4, 5]. Crystals referable to this type are quite common, being noted in as many as eight specimens. They are of rhombohedral habit, the preponderance of the rhombohedron c. $(0.13.\bar{13}.1)$ giving to them an aspect almost prismatic. The rhombohedron η. $(04\bar{4}5)$, which with δ. $(01\bar{1}2)$ terminates the type is of variable development from a face equal to δ. $(01\bar{1}2)$ in habit to a mere line, as in figure 4. Vicinal planes are frequent in crystals of this type and are often present to such an extent as to modify the basal edges to curved lines and give to the crystal the aspect shown in figure 5. Twinning parallel to the basal plane o was noted.

Type V [pl. 26, fig. 6, 7]. A combination of rhombohedral habit referable to this type is shown in figure 6, the dominant forms being the negative rhombohedrons δ. $(01\bar{1}2)$ and a new negative rhombohedron $(07\bar{7}1)$ to which the letter Q. has been assigned. The negative rhombohedron φ. $(02\bar{2}1)$ is present in small development as well as the prism a $(11\bar{2}0)$ and the negative scalenohedron Y $(12.32.\bar{44}.13)$. The latter form was noted by vom Rath[2] on the calcite from Bergen Hill, N. J. A more complex combination of this type, shown in figure 7, is of rhombohedral-scalenohedral

[1] Melczer, G. Földtani Közlöny 1896, 26:79.

[2] vom Rath, G. Zeitschr. f. Kryst. 1877. 1:604.

habit. The rhombohedral zone in this instance is composed of the negative rhombohedrons δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, Φ. $(0.14.\bar{14}.1)$ and T. $(0.28.\bar{28}.1)$ developed to about equal habit. The positive scalenohedron K: $(21\bar{3}1)$ is present, developed to a considerable habit; the planes of this scalenohedron are striated parallel to the zone $[10\bar{1}1.11\bar{2}0]$. The negative scalenohedron Y noted in the preceding combination is here present in small development, the planes in both instances giving good reflections. The dihexagonal prism ς $(31\bar{4}0)$ is also present in planes of relative small development which yield fair reflections.

Type VI [pl. 27, fig. 1, 2.] A combination of this type, represented by small, yellowish, rhombohedral crystals, is shown, in figure 1. These crystals, which were in few instances observed to be doubly terminated, have for the dominant form the negative rhombohedron F. $(0.12.\bar{12}.5)$ present as a series of roughened and somewhat rounded planes. The prism b $(10\bar{1}0)$, also represented by rounded planes marked by vicinal prominences, merges into F. with no sharply marked edge. Small bright planes of the rhombohedron p. $(10\bar{1}1)$ modify the polar edges of F. The combination which is shown in figure 2 and which is evidently of a built-up character was observed on several specimens in individuals averaging 5 millimeters in length. These are rhombohedral in habit the compound individual consisting of a steep rhombohedral element combining the negative rhombohedrons φ. $(02\bar{2}1)$, F. $(0.12.\bar{12}.5)$ and ω. $(0.11.\bar{11}.4)$ developed to about equal habit; this middle section is terminated by a superposed element in parallel position combining the negative rhombohedrons δ. $(01\bar{1}2)$ and Ψ. $(0.17.\bar{17}.1)$. Reentering angles mark the juncture of the superposed elements as shown in figure 2a which represents a section normal to the rhombohedral zone.

Type VII [pl. 27, fig. 3, 4]. Crystals of this type are notably larger than those heretofore described and are characterized by rather dull faces. The combination shown in figure 3 consists of the positive scalenohedrons H: $(31\bar{4}2)$ and 𝔳 $(10.3.\bar{13}.2)$ terminated with the rhombohedron $(01\bar{1}2)$. Of these the scalenohedron H: $(31\bar{4}2)$ is represented by dull and roughened

faces and the scalenohedron N: $(53\bar{8}2)$ is frequently absent from crystals of this type. Pyrite inclusions are present on, or just below, the surface δ. $(01\bar{1}2)$, as distinct bands outlining the symmetry along the edges of p. $(10\bar{1}1)$ and often terminating in brushes; in some cases noted, these bands were connected by lateral extensions along the basal edges of p. $(10\bar{1}1)$. Phantoms of opaque white calcite which are shown on the cleavage and take the form of the rhombohedron p. $(10\bar{1}1)$ suggest the secondary derivation of this type from a simpler primitive crystal. Another combination clearly referable to this type is shown in figure 4. Crystals of this phase are rhombohedral-scalenohedral in habit, having for dominant forms the negative rhombohedron δ. $(01\bar{1}2)$, the positive rhombohedron z. $(28.0.\overline{28}.1)$ and the positive scalenohedron $\mathfrak{v}$ $(10.3.\overline{13}.2)$. Striated planes of the positive scalenohedron L: $(17.9.\overline{26}.8)$ are present in small development. The presence of the scalenohedron $\mathfrak{v}$ seems to connect this type with the combinations previously noted from the vicinity of Catskill, an analogy which is borne out by the presence of the scalenohedron H: of the zone $[10\bar{1}1.11\bar{2}0]$ in both occurrences.

Type VIII [pl. 27, fig. 5]. Crystals of this type are scalenohedral in habit, of rhombohedral aspect and combine forms of the zone $[01\bar{1}2.10\bar{1}1.11\bar{2}0]$. Of these the faces composing the middle band are those of the scalenohedron D: $(61\bar{7}5)$ while those which, with the negative rhombohedron δ. $(01\bar{1}2)$, form the termination are built-up faces composed of the rhombohedron p. $(10\bar{1}1)$ and the scalenohedron f: $(7.2.\bar{9}.11)$ though the presence of vicinal planes and striations render the measurements obtained from these faces vague and the scalenohedral form uncertain. The zonal edges of D: are beveled by narrow bright planes of the scalenohedron G: $(72\bar{9}5)$. The presence of pyrite inclusions arranged on the phantom faces of the rhombohedron p. $(10\bar{1}1)$ suggests that crystals of this type were produced by a "building-up" process from secondary calcareous solutions upon primitive, rhombohedral crystals. Small amounts of galena and sphalerite were found associated with this phase of the Rondout calcite.

Type IX [pl. 27, fig. 6]. The rhombohedron p. $(10\bar{1}1)$ which gives

to crystals of this type a distinct rhombohedral habit, is represented by large dull faces. The rhombohedron δ. $(01\bar{1}2)$ which modifies the terminal edges and the prism a $(11\bar{2}0)$ which modifies the basal edges of p. $(10\bar{1}1)$ are present as narrow bright faces. The scalenohedron $\mathfrak{D}$ $(15.4.\overline{19}.3)$ is occasionally present as a modification represented by small faces of medium brilliancy.

DISTRIBUTION OF FORMS

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	TYPE I	TYPE II	TYPE III	TYPE IV	TYPE V	TYPE VI	TYPE VII	TYPE VIII	TYPE IX
o	0P	0001	...	x	...	...	...	...	...	...	....
a	∞ P2	$11\bar{2}0$	...	x	x	...	x	...	...	...	x
b	∞ R	$10\bar{1}0$	x	...	...	...	...	x	...	...	....
ς	∞ R2	$31\bar{4}0$	...	...	...	...	x	...	...	...	....
z.	28R	$28.0.\overline{28}.1$	...	...	...	...	...	...	x	...	....
m.	4R	$40\bar{4}1$	...	x	...	...	...	...	...	...	....
p.	R	$10\bar{1}1$	...	...	x	...	...	x	...	...	x
δ.	$-\frac{1}{2}R$	$01\bar{1}2$	x	x	x	x	x	x	x	x	x
η.	$-\frac{4}{5}R$	$04\bar{4}5$	...	...	...	x	...	...	...	...	....
φ.	$-2R$	$02\bar{2}1$	...	...	...	...	x	x	...	...	....
F.	$-\frac{12}{5}R$	$0.12.\overline{12}.5$	...	...	...	...	...	x	...	...	....
ω.	$-\frac{11}{4}R$	$0.11.\overline{11}.4$	...	...	...	...	...	x	...	...	....
Δ.	$-\frac{7}{2}R$	$07\bar{7}2$	...	x	...	...	...	...	...	...	....
Q.	$-7R$	$07\bar{7}1$	...	...	...	...	x	...	...	...	....
C.	$-13R$	$0.13.\overline{13}.1$	...	...	...	...	x	...	...	...	....
Φ.	$-14R$	$0.14.\overline{14}.1$	...	...	...	x	...	...	...	...	....
Ψ.	$-17R$	$0.17.\overline{17}.1$	...	...	...	...	...	x	...	...	....
T.	$-28R$	$0.28.\overline{28}.1$	...	...	...	...	x	...	...	...	....
f:	$\frac{5}{11}R\frac{9}{5}$	$7.2.\bar{9}.11$	...	...	...	...	...	...	...	x	....
D:	$R\frac{7}{5}$	$61\bar{7}5$	...	...	...	...	...	...	...	x	....
G:	$R\frac{9}{5}$	$72\bar{9}5$	...	...	...	...	...	...	...	x	....
H:	R2	$31\bar{4}2$	...	...	...	...	...	...	x	...	....
K:	R3	$21\bar{3}1$	...	...	x	...	x	...	...	...	....
L:	$R\frac{13}{4}$	$17.9.\overline{26}.8$	...	...	...	...	...	...	x	...	....
$\mathfrak{v}$	$\frac{7}{2}R\frac{13}{7}$	$10.3.\overline{13}.2$	...	...	...	...	...	...	x	...	....
$\mathfrak{D}$	$\frac{11}{3}R\frac{19}{11}$	$15.4.\overline{19}.3$	...	x	x	...	...	...	...	...	x
Y	$-\frac{20}{13}R\frac{11}{5}$	$12.32.\overline{44}.13$	...	...	...	...	x	...	...	...	....
$\mathfrak{y}$	$-\frac{13}{2}R\frac{19}{13}$	$3.16.\overline{19}.2$	...	...	x	...	...	...	...	...	....
$\mathfrak{x}$	$-6R\frac{3}{2}$	3.15.18.2	...	...	x	...	...	...	...	...	....

SUMMARY OF MEASURED AND CALCULATED ANGLES

LETTER	ANGLE	NO. OF READINGS	MEASURED		CALCULATED	
			°	′	°	′
$\varsigma : \varsigma^{v}$	$31\bar{4}0 : 4\bar{1}\bar{3}0$	7	27	34	27	48
$\delta. : z.$	$10\bar{1}\bar{2} : 28.0.\overline{28}.1$	6	65	56	65	49
$\delta. : \eta.$	$01\bar{1}2 : 04\bar{4}5$	2	12	3	12	2
$\delta. : \varphi.$	$01\bar{1}2 : 02\bar{2}1$	7	36	58½	36	52
$\delta. : F.$	$01\bar{1}2 : 0.12.\overline{12}.5$	7	40	47	40	46
$F. : F.'$	$0.12.\overline{12}.5 : \overline{12}.0.12.5$	3	105	43	105	50
$\delta. : \omega.$	$01\bar{1}2 : 0.11.\overline{11}.4$	7	43	16	43	31
$\delta. : \Delta.$	$01\bar{1}2 : 07\bar{7}2$	6	47	11	47	36
$\delta. : Q.$	$01\bar{1}2 : 07\bar{7}1$	8	55	53	55	30½
$Q. : Q.$	$07\bar{7}1 : \bar{7}071$	2	61	58½	62	1
$\delta. : C.$	$01\bar{1}2 : 0.13.\overline{13}.1$	8	59	0	59	17½
$\delta. : \Phi.$	$01\bar{1}2 : 0.14.\overline{14}.1$	5	59	48	59	36½
$\delta. : \Psi^{\cdot}.$	$01\bar{1}2 : 0.17.\overline{17}.1$	8	60	24	60	20
$\delta. : T.$	$01\bar{1}2 : 0.28.\overline{28}.1$	6	61	27½	61	41
$f: : f:'$	$7.2.\bar{9}.11 : \bar{7}.9.\bar{2}.11$	2	51	42½	51	59
$f: : f:^{v}$	$7.2.\bar{9}.11 : 9.\bar{2}.\bar{7}.11$	3	14	4	14	23
$D: : D:'$	$61\bar{7}5 : \bar{6}7\bar{1}5$	3	78	1	77	39
$D: : D:^{v}$	$61\bar{7}5 : 7\bar{1}\bar{6}5$	9	12	32	12	0
$D: : D:^{vi}$	$61\bar{7}5 : 16\bar{7}\bar{5}$	9	85	21½	85	59
$G: : G:'$	$72\bar{9}5 : \bar{7}9\bar{2}5$	3	78	16	78	3
$G: : G:^{v}$	$72\bar{9}5 : 9\bar{2}\bar{7}5$	4	21	5	20	44
$p. : G:$	$10\bar{1}1 : 72\bar{9}5$	11	16	22	16	32
$H: : H:^{v}$	$31\bar{4}2 : 4\bar{1}\bar{3}2$	1	24	13	24	10
$H: : H:^{vi}$	$31\bar{4}2 : 13\bar{4}\bar{2}$	2	66	39	66	15½
$\varphi. : K:$	$02\bar{2}1 : 21\bar{3}1$	6	37	34	37	41
$K: : K:^{v}$	$21\bar{3}1 : 3\bar{1}\bar{2}1$	1	35	33	35	36
$L: : L:^{v}$	$17.9.\overline{26}.8 : 26.\bar{9}.\overline{17}.8$	1	37	56	37	29½
$\delta.'' : L:$	$1\bar{1}02 : 17.9.\overline{26}.8$	4	68	24	68	7½
$\mathfrak{d} : \mathfrak{d}'$	$10.3.\overline{13}.2 : \overline{10}.13.\bar{3}.2$	3	92	48	92	46
$\mathfrak{d} : \mathfrak{d}^{v}$	$10.3.\overline{13}.2 : 13.\bar{3}.\overline{10}.2$	5	25	17	25	5
$\mathfrak{d} : \mathfrak{d}^{vi}$	$10.3.\overline{13}.2 : 3.10.\overline{13}.\bar{2}$	7	39	10	39	13
$\mathfrak{D} : \mathfrak{D}'$	$15.4.\overline{19}.3 : \overline{15}.19.\bar{4}.3$	4	95	3	95	2
$\mathfrak{D} : \mathfrak{D}^{v}$	$15.4.\overline{19}.3 : 19.\bar{4}.\overline{15}.3$	7	22	43	22	41
$\mathfrak{D} : \mathfrak{D}^{vi}$	$15.4.\overline{19}.3 : 4.15.\overline{19}.\bar{3}$	8	41	55	41	54
$Y: : Y^{v}$	$12.32.\overline{44}.13 : 44.\overline{32}.\overline{12}.13$	3	83	34	83	41
$Y: : Y'$	$12.32.\overline{44}.13 : \overline{12}.44.\overline{32}.13$	5	29	3	28	58½
$\mathfrak{y} : \mathfrak{y}^{v}$	$3.16.\overline{19}.2 : 19.\overline{16}.\bar{3}.2$	1	101	58	102	6
$\mathfrak{y} : \mathfrak{y}'$	$3.16.\overline{19}.2 : \bar{3}.19.\overline{16}.2$	6	16	45	16	47
$a : \mathfrak{y}$	$11\bar{2}0 : 16.3.\overline{19}.\bar{2}$	7	22	26	22	29
$\mathfrak{x} : \mathfrak{x}$	$3.15.\overline{18}.2 : 18.\overline{15}.\bar{3}.2$	3	101	35	101	4½
$\mathfrak{x} : \mathfrak{x}$	$3.15.\overline{18}.2 : \bar{3}.18.\overline{15}.2$	8	17	12½	17	46
$a : \mathfrak{x}$	$11\bar{2}0 : 3.15.\overline{18}.2$	10	22	21	22	7

THEORETICAL CONCLUSIONS

An examination of the geologic map of New York with relation to the foregoing localities will show that these occurrences are geologically susceptible of division into the following groups:

I Occurrences in the crystalline limestones of the Grenville series in Jefferson, Lewis and St Lawrence counties. These occurrences are: Rossie, Antwerp, Somerville and Sterlingbush.

II Occurrences in veins traversing Adirondack gneiss and in most instances associated with ore bodies of magnetite. These occurrences are: Lyon Mountain, Arnold hill, Mineville and Chilson lake.

III Occurrences in the Trenton limestone of the Champlain-Hudson valley. These occurrences are: Smith's Basin, Glens Falls and Saratoga.

IV Occurrences in locally disturbed Upper Siluric limestone formations of central New York. These occurrences are: Fayetteville and Union Springs.

V Occurrences in the Upper Siluric limestones of the Mohawk-Hudson valley. These occurrences are: Howes Cave, South Bethlehem, New Baltimore, Catskill, Hudson and Rondout.

The following synoptic table gives the distribution of the forms for the 20 occurrences hitherto discussed.

SYNOPTIC TABLE OF DISTRIBUTION OF FORMS OF NEW YORK CALCITE

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	ROSSIE	ANTWERP	SOMERVILLE	STERLINGBUSH	LYON MOUNTAIN	ARNOLD HILL	MINEVILLE	CHILSON LAKE	CROWN POINT	SMITH'S BASIN	GLENS FALLS	SARATOGA	FAYETTEVILLE	UNION SPRINGS	HOWES CAVE	SOUTH BETHLEHEM	NEW BALTIMORE	CATSKILL	HUDSON	RONDOUT	
o	0R	0001	x	x		x				x						x						x	
a	$\infty P2$	$11\bar{2}0$	x		x		x	x		x		x	x	x	x	x	x			x	x	x	
b	∞R	$10\bar{1}0$	x	x	x		x	x		x		x	x	x		x	x	x		x		x	
ς	$\infty R2$	$31\bar{4}0$											x									x	
θ	$\infty R3$	$21\bar{3}0$					x																
μ	$\infty R4$	$53\bar{8}0$										x											new
π	$\frac{2}{3}P2$	$11\bar{2}3$		x			x																
λ	$\frac{4}{3}P2$	$22\bar{4}3$					x																
υ	2P2	$11\bar{2}1$					x																
α	$\frac{8}{3}P2$	$44\bar{8}3$					x							x									
γ	$\frac{16}{3}P2$	$8.8.\overline{16}.3$	x				x							x	x	x							
η	10P2	$5.5.\overline{10}.1$			x																		
φ	16P2	$8.8.\overline{16}.1$			x																		new
z.	+28R	$28.0.\overline{28}.1$																				x	
t.	+16R	$16.0.\overline{16}.1$	x																				
s.	+13R	$13.0.\overline{13}.1$		x	x								x			x		x					
v.	+9R	$90\bar{9}1$		x																			
c.	+8R	$80\bar{8}1$	x																				
q.	+7R	$70\bar{7}1$	x														x	x					
n.	+5R	$50\bar{5}1$	x																				
m.	+4R	$40\bar{4}1$	x	x	x		x					x	x	x	x	x	x	x				x	
p.	R	$10\bar{1}1$	x	x	x	x	x		x		x	x	x	x	x	x	x	x	x		x	x	
δ.	$-\frac{1}{2}R$	$01\bar{1}2$	x	x	x			x			x	x	x	x		x	x	x	x	x		x	
η.	$-\frac{4}{5}R$	$04\bar{4}5$			x		x						x					x				x	
θ.	$-\frac{7}{8}R$	$07\bar{7}8$																x					
χ.	—R	$01\bar{1}1$								x													

ν.	$-\frac{5}{4}R$	$05\bar{5}4$	x				x																
ξ.	$-\frac{4}{3}R$	$04\bar{4}3$	x				x																
Y.	$-\frac{19}{13}R$	$0.19.\bar{19}.13$					x																
ρ.	$-\frac{3}{2}R$	$03\bar{3}2$								x													
σ.	$-\frac{11}{7}R$	$0.11.\bar{11}.7$					x																
φ.	$-2R$	$02\bar{2}1$	x	x	x	x	x		x	x		x		x		x						x	
F.	$-\frac{12}{5}R$	$0.12.\bar{12}.5$																				x	
ψ.	$-\frac{5}{2}R$	$05\bar{5}2$										x											
ω.	$-\frac{11}{4}R$	$0.11.\bar{11}.4$																				x	
J.	$-\frac{13}{4}R$	$0.13.\bar{13}.4$					x																
Δ.	$-\frac{7}{2}R$	$07\bar{7}2$					x															x	
Ξ.	$-5R$	$05\bar{5}1$										x											
Q.	$-7R$	$07\bar{7}1$																				x	new
Π.	$-8R$	$08\bar{8}1$							x														
Σ.	$-11R$	$0.11.\bar{11}.1$					x					x											
C.	$-13R$	$0.13.\bar{13}.1$																				x	
Φ.	$-14R$	$0.14.\bar{14}.1$			x												x					x	
Ψ.	$-17R$	$0.17.\bar{17}.1$																				x	
T.	$-28R$	$0.28.\bar{28}.1$																				x	
x:	$+\frac{1}{10}R7$	$4.3.\bar{7}.10$																x					
v:	$+\frac{1}{5}R\frac{11}{3}$	$7.4.\bar{11}.15$																		x			
w:	$+\frac{2}{5}R2$	$31\bar{4}5$	x																				
f:	$+\frac{5}{11}R\frac{9}{5}$	$7.2.\bar{9}.11$	x																			x	
e:	$+\frac{1}{2}R\frac{5}{3}$	$41\bar{5}6$		x	x												x						
c:	$+\frac{5}{8}R\frac{7}{5}$	$61\bar{7}8$														x							
b:	$+\frac{2}{3}R\frac{4}{3}$	$71\bar{8}9$															x						
D:	$+R\frac{7}{5}$	$61\bar{7}5$			x																	x	
E:	$+R\frac{3}{2}$	$51\bar{6}4$																					
G:	$+R\frac{9}{5}$	$72\bar{9}5$																x		x		x	
H:	$+R2$	$31\bar{4}2$															x			x		x	
K:	$+R3$	$21\bar{3}1$	x	x	x	x	x							x	x	x	x	x	x			x	
L:	$+R\frac{13}{4}$	$17.9.\bar{26}.8$																				x	
:	$+R\frac{7}{2}$	$9.5.\bar{14}.\bar{4}$				x																	
M:	$+R\frac{11}{3}$	$7.4.\bar{11}.3$			x							x				x							
χ:	$+R\frac{23}{6}$	$29.17.\bar{46}.12$												x									
N:	$+R4$	$53\bar{8}2$		x		x				x			x							x			
r:	$+R\frac{24}{5}$	$29.19.\bar{48}.10$						x															new
P:	$+R5$	$32\bar{5}1$				x						x								x			

SYNOPTIC TABLE OF DISTRIBUTION OF FORMS OF NEW YORK CALCITE *(continued)*

LETTER	NAUMANN SYMBOL	BRAVAIS-MILLER SYMBOL	ROSSIE	ANTWERP	SOMERVILLE	STERLINGBUSH	LYON MOUNTAIN	ARNOLD HILL	MINEVILLE	CHILSON LAKE	CROWN POINT	SMITH'S BASIN	GLENS FALLS	SARATOGA	FAYETTEVILLE	UNION SPRINGS	HOWES CAVE	SOUTH BETHLEHEM	NEW BALTIMORE	CATSKILL	HUDSON	RONDOUT	
T:	$+R7$	$43\bar{7}1$	x					x															
θ:	$+R8$	$9.7.\overline{16}.2$										x											
U:	$+R9$	$54\bar{9}1$					x																
V:	$+R11$	$6.5.\overline{11}.1$							x														
ω:	$+R14$	$15.13.\overline{28}.2$										x											
ι:	$+R16$	$17.15.\overline{32}.2$										x											
𝔬:	$-2R\frac{5}{3}$	$2.8.\overline{10}.3$								x													
𝔭:	$-2R2$	$13\bar{4}1$						x				x					x						
𝔮:	$-2R3$	$24\bar{6}1$	x				x																
𝔱:	$-2R\frac{11}{3}$	$8.14.\overline{22}.3$					x																new
𝔯:	$-2R4$	$35\bar{8}1$										x											
𝔰:	$-2R5$	$4.6.\overline{10}.1$	x				x																new
U:	$+2R\frac{7}{3}$	$10.4.\overline{14}.3$															x						
𝔜:	$+\frac{3}{2}R\frac{29}{9}$	$19.10.\overline{29}.6$														x							
𝔘:	$+\frac{2}{5}R13$	$14.12.\overline{26}.5$					x																
𝔛:	$-4R\frac{5}{3}$	$4.16.\overline{20}.3$	x																				
𝔙:	$-\frac{7}{5}R\frac{11}{5}$	$2.9.\overline{11}.5$													x								
Ξ:	$+4R\frac{4}{3}$	$14.2.\overline{16}.3$	x																				
𝔐:	$+4R\frac{5}{3}$	$16.4.\overline{20}.3$																			x		
𝔑:	$+4R\frac{7}{4}$	$11.3.\overline{14}.2$																		x			new
𝔍:	$+4R2$	$62\bar{8}1$	x														x	x					
𝔖:	$+4R\frac{11}{4}$	$15.7.\overline{22}.2$	x																				
𝔎:	$+4R3$	$8.4.\overline{12}.1$					x					x					x						

c:	$-\frac{1}{2}R7$	$34\bar{7}2$					x																
e:	$-\frac{1}{2}R10$	$9.11.\overline{20}.4$						x															
g:	$-\frac{1}{2}R13$	$6.7.\overline{13}.2$		x	x																		
Θ	$-R3$	$12\bar{3}1$														x							
T	$+2R3$	$42\bar{6}1$				x											x						
ℌ	$+\frac{5}{2}R\frac{13}{5}$	$9.4.\overline{13}.2$															x						new
𝔩:	$+3R\frac{9}{4}$	$39.15.\overline{54}.8$	x																				new
𝔳	$+\frac{7}{2}R\frac{13}{7}$	$10.3.\overline{13}.2$																		x		x	
𝔇	$+\frac{11}{3}R\frac{19}{11}$	$15.4.\overline{19}.3$																				x	
Y	$-\frac{20}{13}R\frac{11}{5}$	$12.32.\overline{44}.13$																				x	
𝔶	$-\frac{13}{2}R\frac{19}{13}$	$3.16.\overline{19}.2$																				x	
𝔢	$-5R\frac{6}{5}$	$1.11.\overline{12}.2$			x																		new
𝔯	$-6R\frac{3}{2}$	$3.15.\overline{18}.2$														x						x	new

Examination of the table on pages 128–31, with reference to the geologic grouping of the localities under consideration reveals, in addition to the preponderance of forms frequent in calcite combinations, such as the prisms a $(11\bar{2}0)$and b $(10\bar{1}0)$, the rhombohedrons m. $(40\bar{4}1)$, p. $(10\bar{1}1)$, δ. $(01\bar{1}2)$ and φ. $(02\bar{2}1)$, and the scalenohedron K: $(21\bar{3}1)$, a coincidence of certain zones with respect to the geologic groupings of occurrences suggestive of the influence of genetic conditions upon the crystal habit of these calcite occurrences. Discussing these in order we have:

Zone of the second order pyramids. The second order pyramids have hitherto been considered as of rare occurrence in calcite combinations; the pyramid γ $(8.8.\overline{16}.3)$, which has been most frequently noted in the literature of calcite, is recorded from some 12 localities.[1]

This pyramid which marks the intersection of three prominent zones is also a member of the most frequently occurring series of pyramids, including π $(11\bar{2}3)$, λ $(22\bar{4}3)$, α $(44\bar{8}3)$ and γ $(8.8.\overline{16}.3)$. It occurs in 5 of the 20 occurrences under discussion, viz: Rossie, Lyon Mountain, Saratoga, Fayetteville and Union Springs, and in two of these, viz: Lyon Mountain and Union Springs, is developed to the extent of a dominant form. At Union Springs the pyramidal habit is specially characteristic of calcite

[1] The second order pyramid $(8.8.\overline{16}.3)$ has been recorded from:

Andreasberg. vom Rath, G. Pogg. Ann. 1867. 132:521.
Agaete. Hessenberg, F. Min. Notizen. 1870. 9:9.
Bamle. Morton, C. Kongl. Sc. Vet. Akad. Förh. 1884. 8:65.
Arlberg. von Foullon, H. Jahrb. geol. Reichsanst. Wien. 1885. 35:47.
Rhisnes. vom Rath, G. Sitz. Niederrhein. Ges. 1886.
Villers en Fagne. Cesàro, G. Soc. Géol. Belg. Ann. 1887.
Kongsberg. Sansoni, F. Giorn. d. Min. 1890. 1:129.
Seilles. Cesàro, G. Soc. Géol. Belg. Ann. 1892. 19:267.
Wisbey. Hamberg, A. Geol. Fören. Förh. 1894. 16:709.
Bad Lands, S. D. Penfield, S. L. & Ford, W. E. Am. Jour. Sci. 1900. 9:352.
Gräsberg. Weibull, M. Geol. Fören. Förh. 1900. 22:19.
Upper Missouri. Rogers, A. F. Am. Jour. Sci. 1901. 12:42.
Bellevue, Ohio. Farrington, O. C. Field Col. Mus. 1908. 3:144.

crystals of the first generation, the highest development of the pyramid being found on crystals of type I.

Comparing the occurring forms of the first generation of Union Springs calcite with the forms recorded by Cesàro[1] from Rhisnes, the striking fact is brought out that 12 of the 14 forms occurring at Union Springs also occur at Rhisnes, one of which, $\mathfrak{Y}$: $(19.10.\overline{29}.6)$, has been observed only at these two localities.

It is apparent, from the position occupied by crystals of type I from Union Springs, which is always that of close proximity to the walls of the seam, that the pyramidal type here occupies the lowest place in the crystal development, representing the oldest generation of calcite. It is equally certain that the scalenohedral type is predominant in crystals of the second generation which might possibly have been, in a measure, derived from the re-solution of the first generation of calcite. Cesàro finds evidence that many of the crystals from Rhisnes of the first generation have been formed around a parent crystal having γ $(8.8.\overline{16}.3)$ as the dominant form.

He announces a theory of genesis of these crystals as follows:

> The examination of these crystals has led us to the conclusion that they have been formed encircling a preexisting second order pyramid and were deposited by the action of three successive mediums: the first producing pyramidal types, the second forming around the first a combination, the faces of which are truncations of the lateral edges of γ, the third depositing around the second stage a crystal having for fundamental forms scalenohedrons of the zone $[10\overline{1}1.11\overline{2}0]$.

This sequence of crystal formation is in accord with that stated above with reference to the Union Springs calcites, the analogy being further emphasized by a comparison of figures 1 and 2 of plate 18 and figure 5 of plate 19. Cesàro also points out the fact that the pyramid γ occurs also on the calcite crystals from Andreasberg as first noted by vom Rath in 1867;[2] he compares the forms of the Rhisnes calcites with those found by Sansoni at Andreasberg and points out several similarities.

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[1] Cesàro, G. Les Formes Cristallines de la Calcite de Rhisnes. Soc. Géol. Belg. Ann. 1889. 16:317.

[2] *Loc. cit.*

Both Rhisnes and Andreasberg lie in the horizon of the Devonic and Upper Carbonic rocks and present the phase of subordinate beds of limestone overlaid by graywacke, clay slate, silicious slate and quartzite. In the vicinity of Andreasberg, these strata are frequently broken through by granite masses.[1] These conditions show a marked analogy to those existing at Union Springs and at Fayetteville, where the limestone beds are overlaid by the shale and silicious slate of the Marcellus and Hamilton groups and show evidences of considerable local disturbance. The limestone on which the Union Springs pyramidal calcite crystals are deposited is unique in that the silicious residue obtained from its solution consists of minute but perfectly formed quartz crystals. As pointed out by Penfield and Ford[2] pyramidal crystals of calcite, of the form ($8.8.\overline{16}.3$) and containing nearly 50 % quartz sand, have been found in the Bad Lands of South Dakota. It would therefore appear that in at least two localities producing the pyramid γ as a crystal habit, the occurrence is marked by the presence of silica under rather unusual circumstances. When we add to this fact the equally significant one that the formation at Union Springs and Fayetteville and at the Belgium and Hartz localities show in each instance disturbed limestone beds overlaid by strata rich in silica, we would seem to have reason for connecting the pyramidal habit of calcite with a crystallizing solution carrying silica in quantities approaching saturation.

Applying this theory to the occurrence at Lyon Mountain, the conclusions drawn from the Union Springs occurrence, where a single pyramid γ ($8.8.\overline{16}.3$) was used as a basis of comparison between the Union Springs calcite and that from Rhisnes and Andreasberg, gain added force in the case of Lyon Mountain, where a series of five pyramids occur in the various types, four of which pyramids are found on the Rhisnes calcites and three of which also occur on the Andreasberg crystals. The dominant

[1] Phillips, J. A. & Louis, Henry. A Treatise on Ore Deposits. 1896. p. 384.

[2] Penfield, S. L. & Ford, W. E. Silicious Calcites from the Bad Lands, Washington County, S. D. Am. Jour. Sci. 1900. 9:352.

form of a combination illustrated by Luedecke[1] under type VIII from Jacobsglück vein, Andreasberg, U: $(54\bar{9}1)$, is identical with the dominant form of type I from Lyon Mountain. He notes this type as occurring sparingly with quartz, which latter mineral has a "*hacked, corroded appearance.*" The mine waters from this immediate locality carry considerable gypsum, epsomite, limonite and hematite in solution and give evidence of having been strongly corrosive. These facts are in perfect accord with the conditions noted in connection with type I from Lyon Mountain [p. 82, 83], and it seems highly probable that in the case of the Jacobsglück vein, Andreasberg and the Lyon Mountain localities, the first stage of calcite deposition took place from a highly corrosive solution which was taking up silica while depositing crystals of the steep scalenohedral habit of calcite. The absence of all secondary quartz in connection with this habit in both localities, points to the fact that the primary quartz in both cases was still being dissolved, and its subsequent appearance with calcite crystals of a later generation, which latter are characterized by an unusual series of second order pyramids, seems to connect beyond question, the pyramidal habit of calcite with a crystallizing solution saturated or nearly saturated with silica.

Pyramids of the second order occur in combination on the calcite from all the localities of group I with the exception of Sterlingbush. With regard to this latter occurrence, the conditions of calcite formation appear to vary widely from those prevailing in the other localities of the group and the enormous crystals which characterize it may be said to represent an advanced stage of calcite deposition absent from these latter. The crystalline limestone which furnished the calcite crystals of Rossie, Antwerp and Somerville lie in close proximity to the Potsdam sandstone which may fairly be supposed to have furnished considerable silica to the crystallizing solutions producing the calcite of these occurrences.

Passing to the occurrence at Saratoga the coincidence of dissolved silica with the presence of the pyramidal zone is much more obvious. Not

[1] Luedecke, Otto. Die Minerale des Harzes. Berlin 1896. pl. 20, fig. 1.

only does the overlying strata of limestone contain numerous included flint nodules, but the limestone in immediate association with the calcite crystals gives on solution a residue of minute quartz crystals similar to the residue from the Union Springs limestone. The presence of crystallized quartz in connection with the occurrence gives additional evidence of a crystallizing solution highly charged with silica.

Zone [$40\bar{4}1 . 11\bar{2}0$]. Forms in this zone although to an extent distributed throughout the 20 localities discussed appear to be quite consistently present on the crystals from the localities of group V, the only notable exception being that of Rondout. With respect to this latter occurrence, it is interesting to note in this connection that the scalenohedron $\mathfrak{D}$ ($15.4.\overline{19}.3$), particularly characteristic of the Rondout calcite, lies close to the zone under consideration, and that its presence might well be due to some local influence operating to disturb the equilibrium of the crystallizing forces. The fact that the occurrences of group V, so closely related with respect to geologic conditions, are characterized by a series of scalenohedrons closely related crystallographically is at least suggestive.

Zone [$01\bar{1}2 . 11\bar{2}0$]. The negative scalenohedrons of this zone occur on calcite crystals from four localities, viz: Antwerp, Somerville, Lyon Mountain and Arnold Hill. With the single exception of Mineville, where the type studied was obviously representative of an early generation of calcite formation, these four localities represent all the occurrences of calcite associated with iron ore included in this work. The coincidence of this set of conditions with the production of crystal forms closely related in zone is again suggestive.

DESCRIPTION OF PLATES

PLATE 3

Calcite from Rossie, St Lawrence co.

Page 59

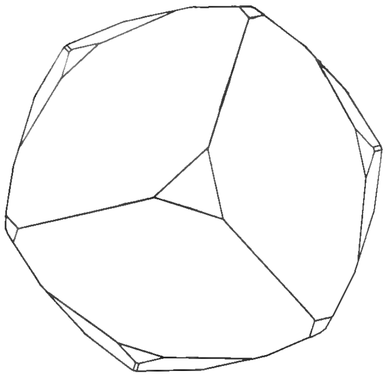
1 Type I after Zippe's, 1852. Forms: P = p. $(10\bar{1}1)$, m = m. $(40\bar{4}1)$ and v = $\mathfrak{J}$: $(62\bar{8}1)$

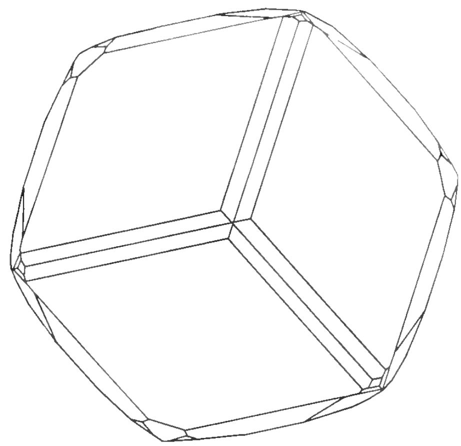
2 Type I, orthographic and clinographic projections. Forms: o (0001), a $(11\bar{2}0)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, q. $(70\bar{7}1)$, φ. $(02\bar{2}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

3 Type II, orthographic and clinographic projections. Forms: p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, φ. $(02\bar{2}1)$, f: $(7.2.\bar{9}.11)$, K: $(21\bar{3}1)$, $\mathfrak{q}$: $(24\bar{6}1)$, $\mathfrak{s}$: $(4.6.\overline{10}.1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

4 Type III. Forms: b $(10\bar{1}0)$, γ $(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, n. $(50\bar{5}1)$, φ. $(02\bar{2}1)$, δ. $(01\bar{1}2)$, K: $(21\bar{3}1)$, $\mathfrak{q}$: $(24\bar{6}1)$, $\mathfrak{s}$: $(4.6.\overline{10}.1)$, Ξ: $(14.2.\overline{16}.3)$, $\mathfrak{J}$: $(62\bar{8}1)$, $\mathfrak{S}$: $(15.7.\overline{22}.2)$ and $\mathfrak{l}$: $(39.15.\overline{54}.8)$

5 Type III, after Hessenberg, 1860. Forms: 0R = o (0001), R = p. $(10\bar{1}1)$, 4R = m. $(40\bar{4}1)$, 4R2 = $\mathfrak{J}$: $(62\bar{8}1)$, $2R^{\frac{1}{4}1} = (15.7.\overline{22}.4)$ and $\frac{3}{3}\frac{2}{5}R^{\frac{1}{4}1} = (60.28.\overline{88}.35)$





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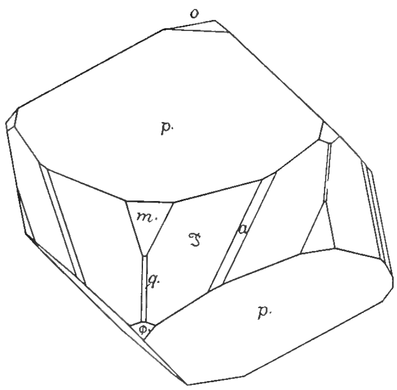

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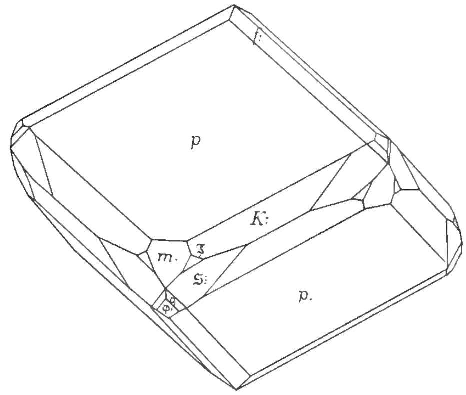

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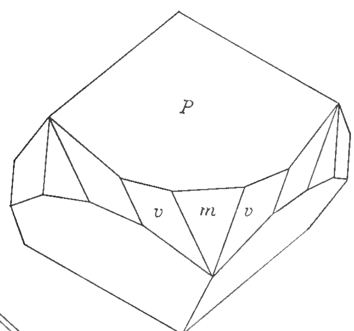

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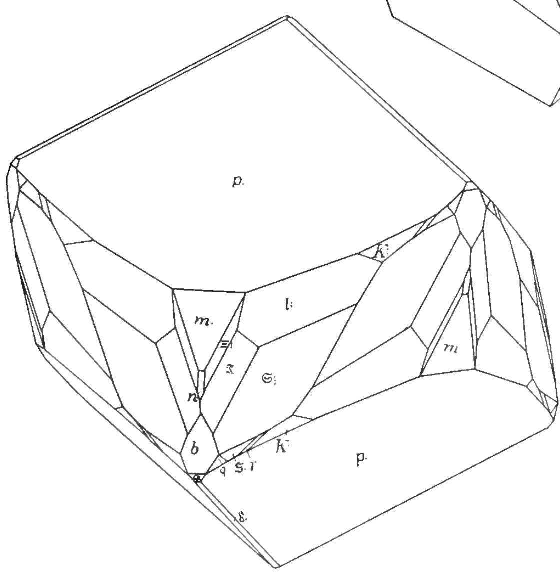

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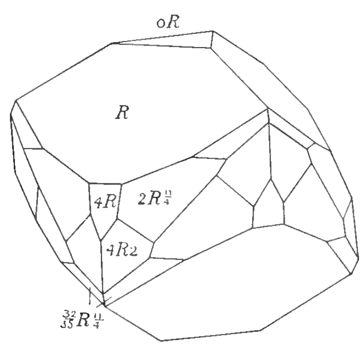

H. P. W. del.

PLATE 4

Calcite from Rossie, St Lawrence co.

Page 65

1 Type IV. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, $\gamma\,(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, c. $(80\bar{8}1)$, t. $(16.0.\overline{16}.1)$, δ. $(01\bar{1}2)$, w: $(31\bar{4}5)$, K: $(21\bar{3}1)$, T: $(43\bar{7}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

2 Twin of type I. Forms: p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, K: $(21\bar{3}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

3 Twin of type I. Forms: o (0001), p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, q. $(70\bar{7}1)$, K: $(21\bar{3}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

4 Twin of type III. Forms: o (0001), p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, $\mathfrak{J}$: $(62\bar{8}1)$ and $\mathfrak{l}$: $(39.15.\overline{54}.8)$

5 Twin of type III. Forms: o (0001), p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, φ. $(02\bar{2}1)$, δ. $(01\bar{1}2)$, K: $(21\bar{3}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

6 Twin of type IV. Forms: $\gamma\,(8.8.\overline{16}.3)$, m. $(40\bar{4}1)$, k. $(11.0.\overline{11}.1)$ w: $(31\bar{4}5)$, K: $(21\bar{3}1)$, and $\mathfrak{Y}$: $(19.10.\overline{29}.6)$?

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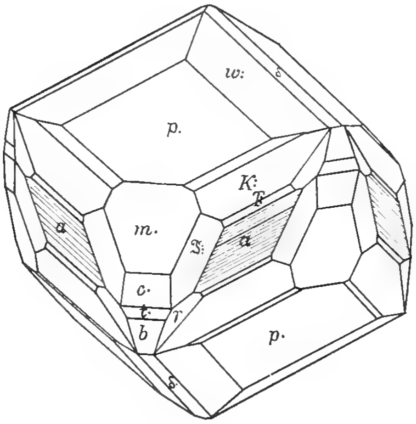

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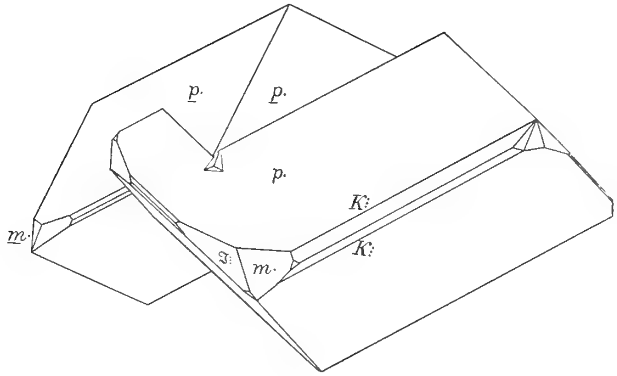

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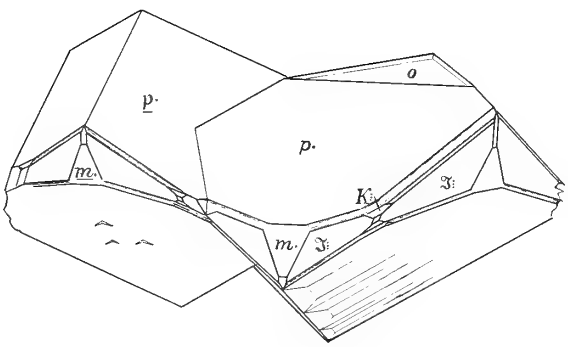

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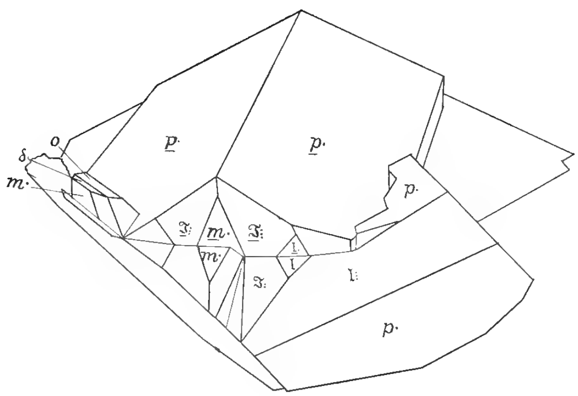

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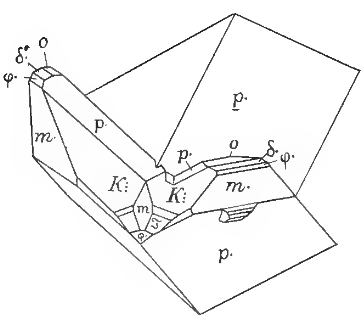

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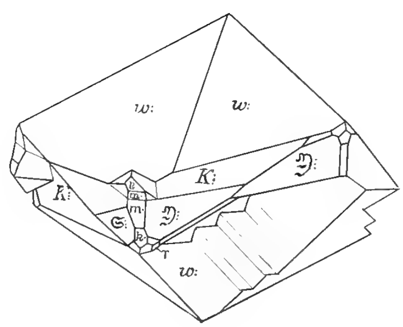

H. P. W. del.

PLATE 5

Calcite from Rossie, St Lawrence co.

Page 66

1 Stereographic projection of the occurring forms

2 Natural etch figures on basal pinacoid o (0001)

3 Natural etch figures on plane of p. $(10\bar{1}1)$

4 Natural etch figures on planes of m. $(40\bar{4}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

5 Natural etch figures on planes of $\mathfrak{l}$: $(39.15.\overline{54}.8)$

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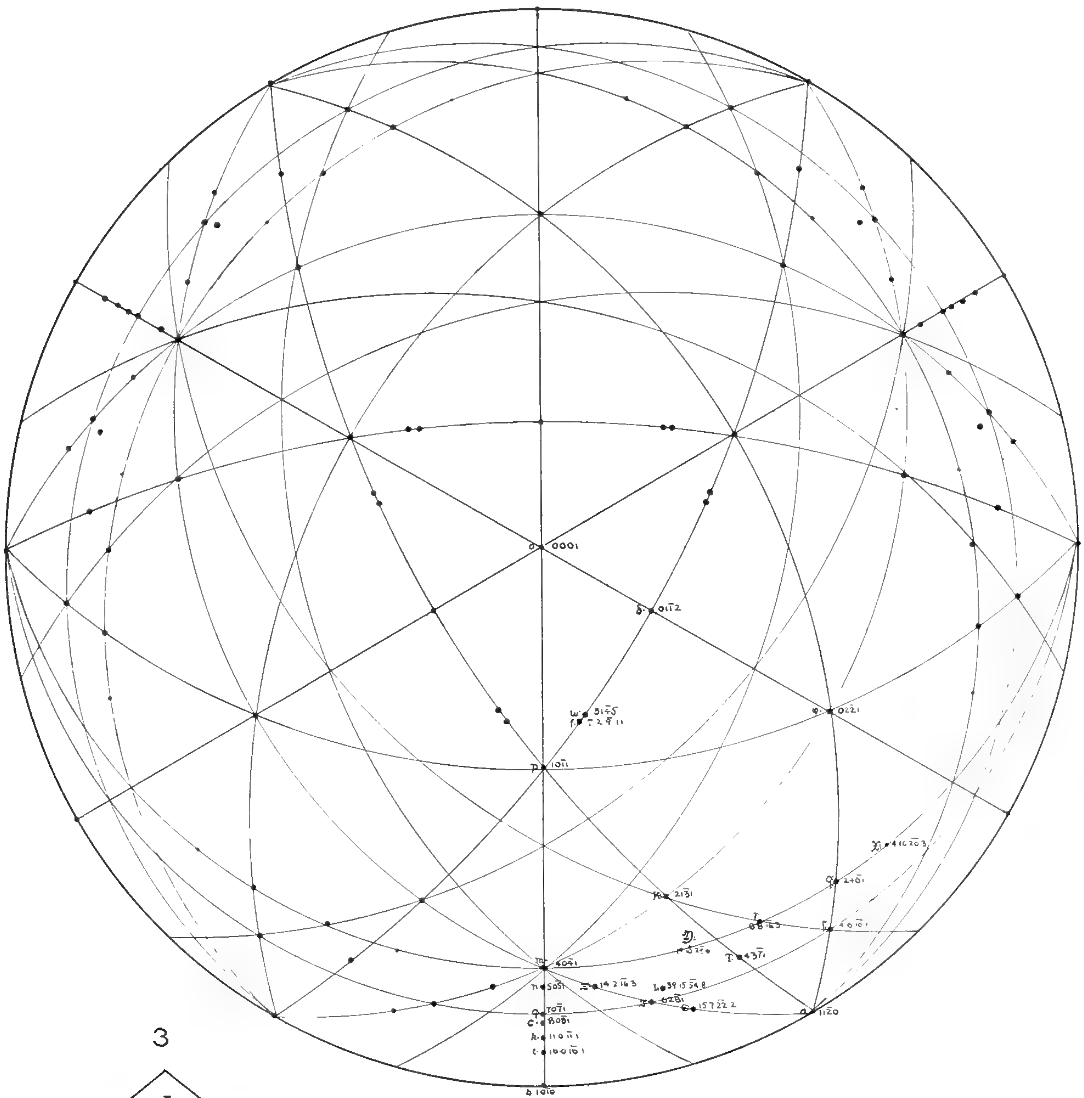

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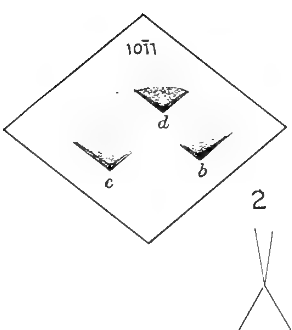

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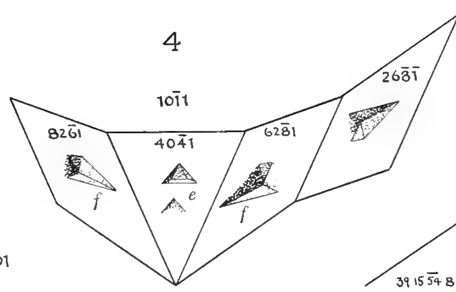

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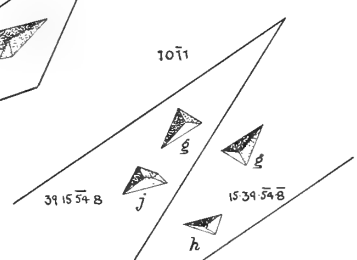

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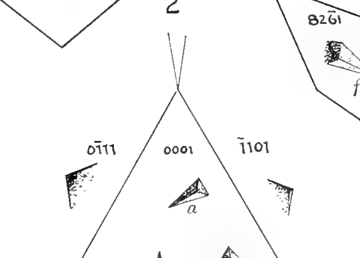

H. P. W. del.

PLATE 6

Calcite from Antwerp, Jefferson co.

Page 71

1 Type I. Forms: o (0001), b. $(10\bar{1}0)$, p. $(10\bar{1}1)$, K: $(21\bar{3}1)$ and g: $(6.7.\overline{13}.2)$

2 Type II. Forms: b $(10\bar{1}0)$ and δ. $(01\bar{1}2)$

3 Type II. Forms: b $(10\bar{1}0)$, v. $(90\bar{9}1)$, δ. $(01\bar{1}2)$ and g: $(6.7.\overline{13}.2)$

4 Type II. Forms: b $(10\bar{1}0)$, s. $(13.0.\overline{13}.1)$, δ. $(01\bar{1}2)$ and g: $(6.7.\overline{13}.2)$

5 Type III. Forms: π $(11\bar{2}3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, φ. $(02\bar{2}1)$, e: $(41\bar{5}6)$ and K: $(21\bar{3}1)$

6 Type III. Forms: π $(11\bar{2}3)$, p. $(10\bar{1}1)$, φ. $(02\bar{2}1)$, e: $(41\bar{5}6)$ and K: $(21\bar{3}1)$

CALCITES

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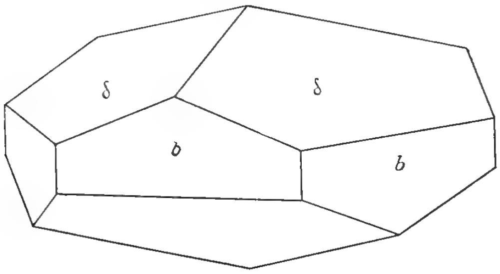

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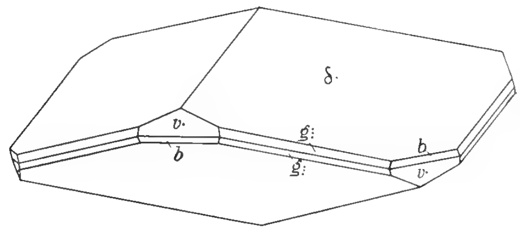

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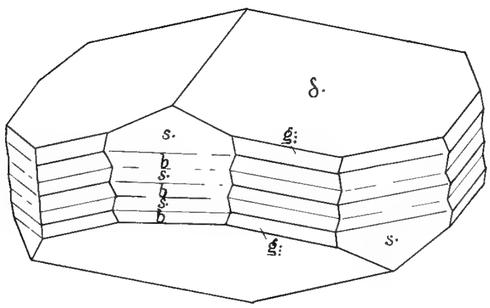

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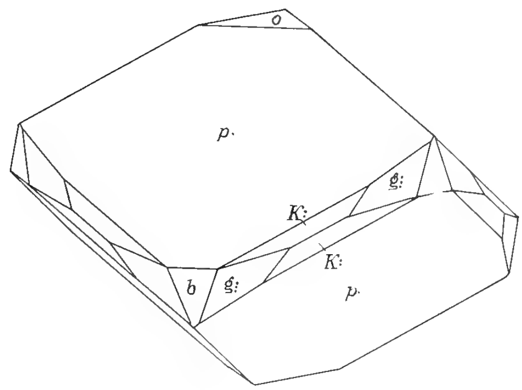

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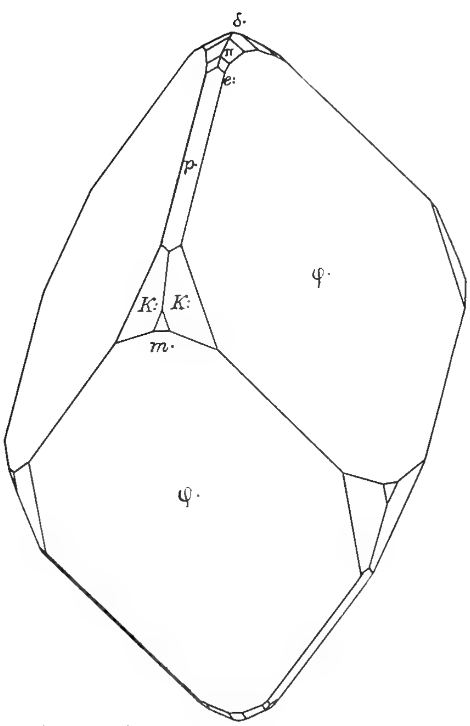

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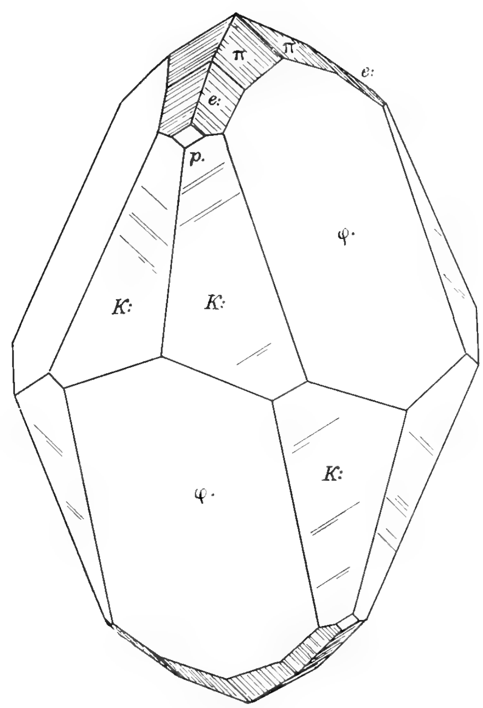

H. P. W. del.

PLATE 7

145

Calcite from Somerville, St Lawrence co.

Page 74

1 Type I. Forms: b. $(10\bar{1}0)$, η $(5.5.\overline{10}.1)$, p. $(10\bar{1}1)$ and δ. $(01\bar{1}2)$

2 Type II. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, φ $(8.8.\overline{16}.1)$, δ. $(01\bar{1}2)$ and K: $(21\bar{3}1)$

3 Type III. Forms: b $(10\bar{1}0)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, s. $(13.0.\overline{13}.1)$, δ $(01\bar{1}2)$, η. $(04\bar{4}5)$, E: $(51\bar{6}4)$ and K: $(21\bar{3}1)$

4 Type IV. Forms: b $(10\bar{1}0)$, δ. $(01\bar{1}2)$ and g: $(6.7.\overline{13}.2)$

5 Type IV. Forms: p. $(10\bar{1}1)$, δ. $(01\bar{1}2)$, c: $(61\bar{7}8)$, K: $(21\bar{3}1)$ and g: $(6.7.\overline{13}.2)$

6 Type V. Scalenohedral habit. Forms: b $(10\bar{1}0)$, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, η. $(04\bar{4}5)$, φ. $(02\bar{2}1)$, Φ. $(0.14.\overline{14}.1)$ and K: $(21\bar{3}1)$

7 Type V. Rhombohedral-scalenohedral habit. Forms: b $(10\bar{1}0)$, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, K: $(21\bar{3}1)$ and ϵ $(1.11.\overline{12}.2)$

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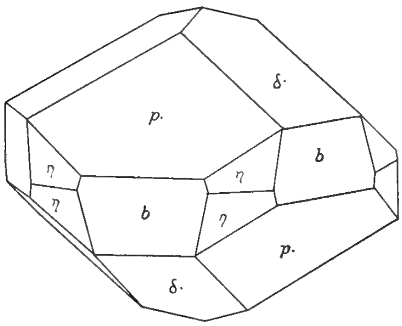

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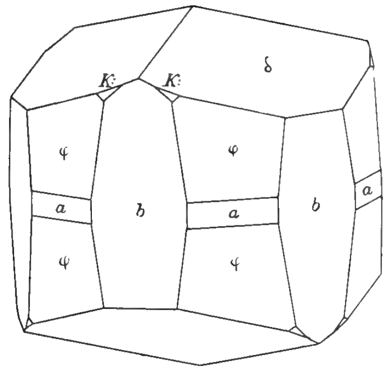

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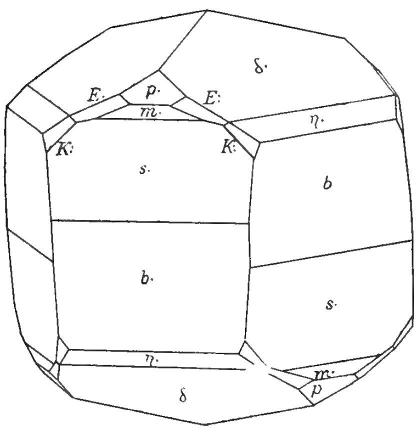

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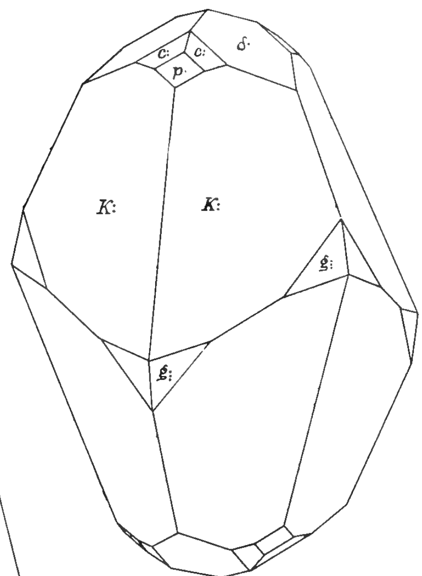

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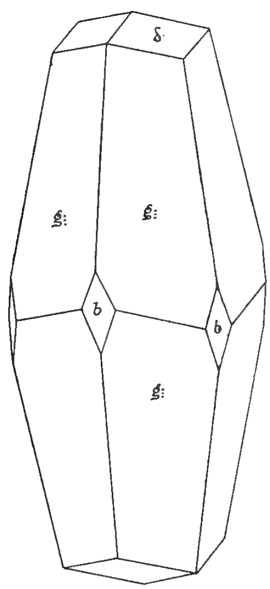

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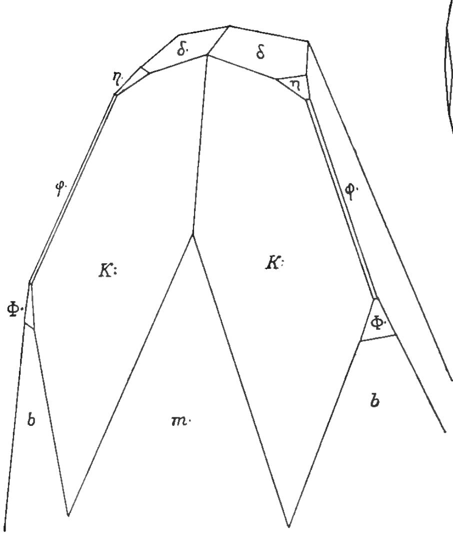

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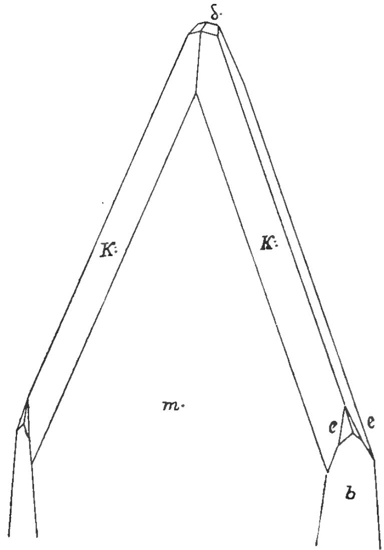


H. P. W. del.

PLATE 8

147

Calcite from Sterlingbush, Lewis co.

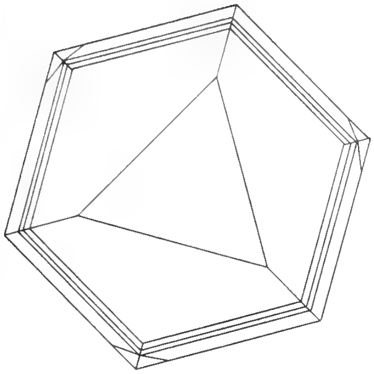
Page 78

1 Average habit of the larger crystals. Orthographic and clinographic projections. Forms: o (0001), p. $(10\bar{1}1)$, K: $(21\bar{3}1)$, N: $(53\bar{8}2)$, P: $(32\bar{5}1)$ and T $(42\bar{6}1)$

2 Scalenohedral habit common to the smaller crystals. Orthographic and clinographic projections. Forms: o (0001), p. $(10\bar{1}1)$, φ. $(02\bar{2}1)$, K: $(21\bar{3}1)$, N: $(52\bar{8}2)$ and P: $(32\bar{5}1)$

3 Twin crystal of scalenohedral habit. Forms: o (0001) and K: $(21\bar{3}1)$

4–6 Twin types of larger crystals. Forms: o (0001), p. $(10\bar{1}1)$ and N: $(53\bar{8}2)$



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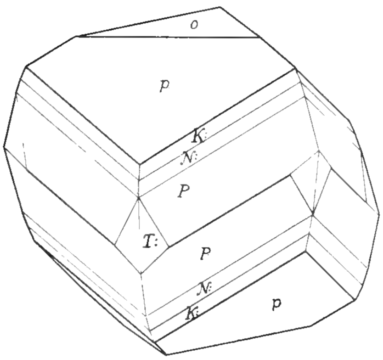

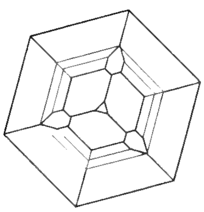

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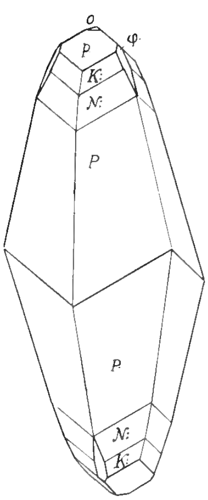

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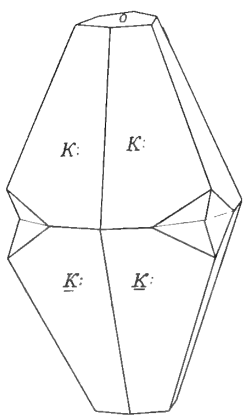

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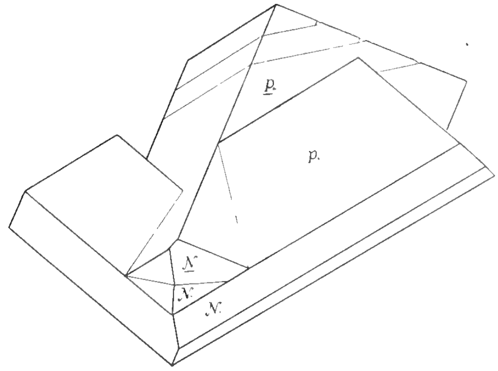

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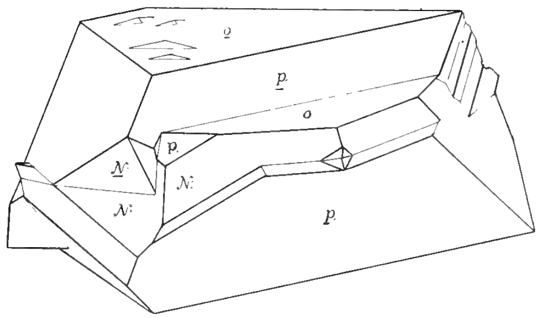

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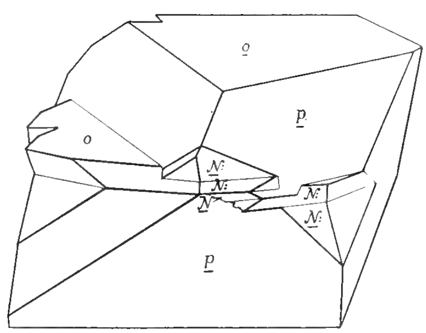

H. P. W. del.

PLATE 9

Calcite from Lyon Mountain, Clinton co.

Page 81

1 Type I. Forms: m. $(40\bar{4}1)$ and U: $(54\bar{9}1)$

2 Type I. Forms: p. $(10\bar{1}1)$, m. $(40\bar{4}1)$ and U: $(54\bar{9}1)$

3 Type I. Forms: m. $(40\bar{4}1)$, J. $(0.13.\bar{13}.4)$ and U: $(54\bar{9}1)$

4 Type II. Forms: Y. $(0.19.\bar{19}.13)$ and q: $(24\bar{6}1)$

5 Type III. Pyramidal habit. Forms: λ $(22\bar{4}3)$, γ $(8.8.\bar{16}.3)$ and Y. $(0.19.\bar{19}.3)$

CALCITES

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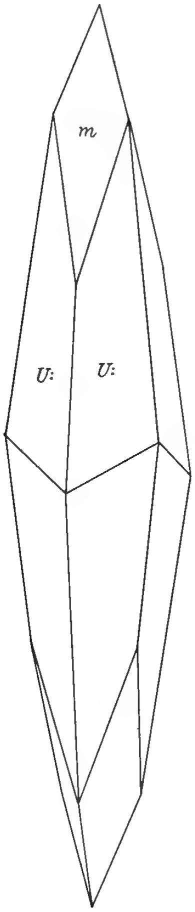

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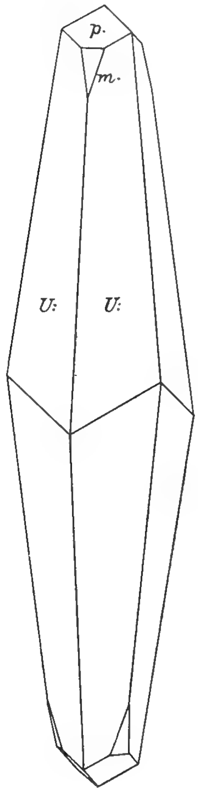

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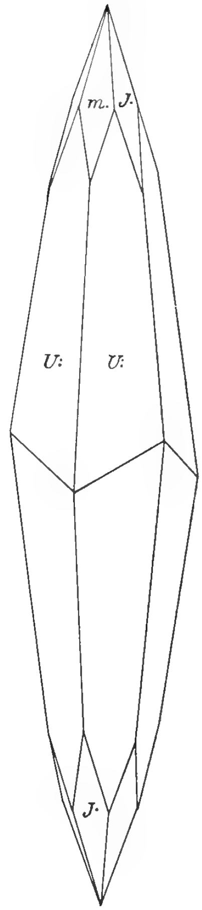

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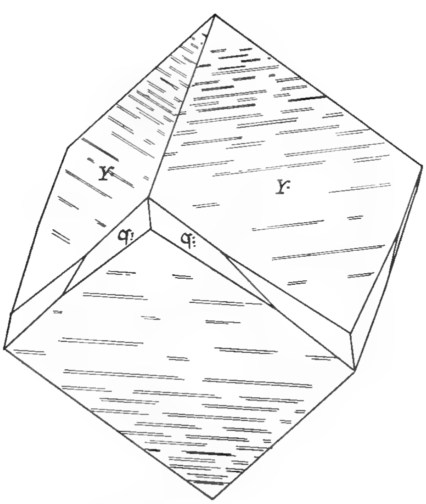

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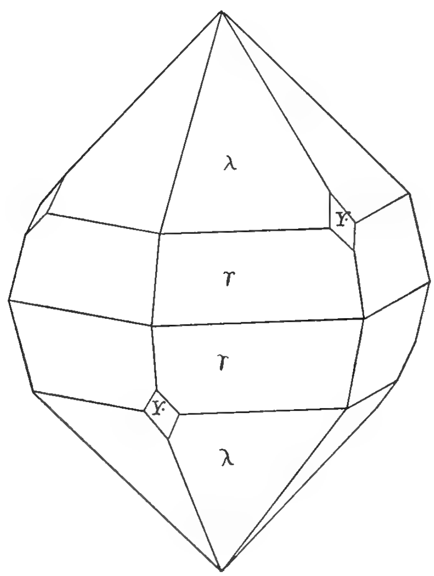


H. P. W. del.

PLATE 10

Calcite from Lyon Mountain, Clinton co.

Page 83

1 Type III. Pyramidal habit. Orthographic and clinographic projections. Forms: λ $(22\bar{4}3)$, γ $(8.8.\overline{16}.3)$, Y. $(0.19.\overline{19}.13)$, K: $(21\bar{3}1)$ and $\mathfrak{S}$: $(4.6.\overline{10}.1)$

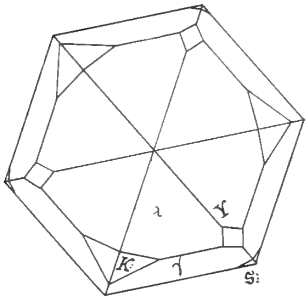
2 Type III. Pyramidal habit. Orthographic and clinographic projections. Forms: λ $(22\bar{4}3)$, γ $(8.8.\overline{16}.3)$, σ. $(0.11.\overline{11}.7)$, Σ. $(0.11.\overline{11}.1)$ and K: $(21\bar{3}1)$

3 Type III. Pyramidal-scalenohedral habit. Orthographic and clinographic projections. Forms: λ $(22\bar{4}3)$, γ $(8.8.\overline{16}.3)$, η. $(04\bar{4}5)$, Y. $(0.19.\overline{19}.13)$, K: $(21\bar{3}1)$ and $\mathfrak{U}$ $(14.12.\overline{26}.5)$

4 Type III. Pyramidal-scalenohedral habit. Orthographic and clinographic projections. Forms: b $(10\bar{1}0)$, λ $(22\bar{4}3)$, ν $(11\bar{2}1)$, γ $(8.8.\overline{16}.3)$, η. $(04\bar{4}5)$, σ. $(0.11.\overline{11}.7)$, φ. $(02\bar{2}1)$, K: $(21\bar{3}1)$ and $\mathfrak{t}$: $(8.14.\overline{22}.3)$

5 Type III. Rhombohedral-pyramidal habit. Forms: λ $(22\bar{4}3)$, γ $(8.8.\overline{16}.3)$, ν. $(05\bar{5}4)$ and φ. $(02\bar{2}1)$

CALCITES



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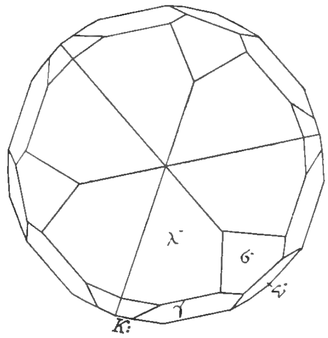

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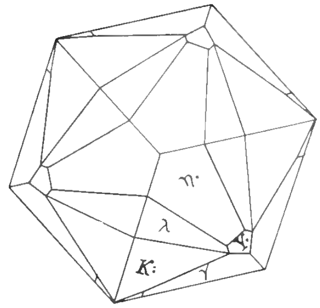

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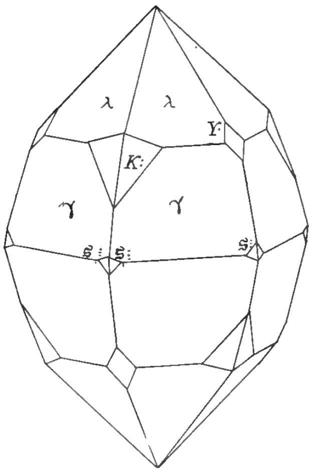

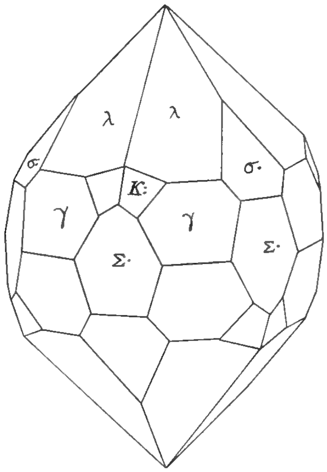

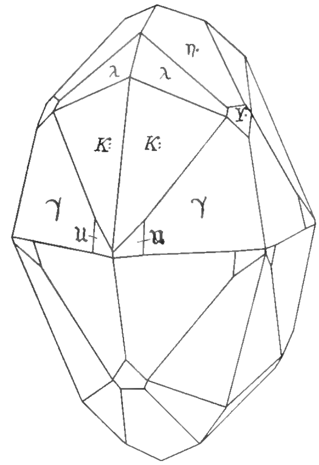

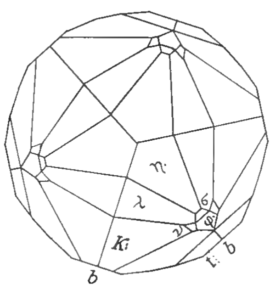

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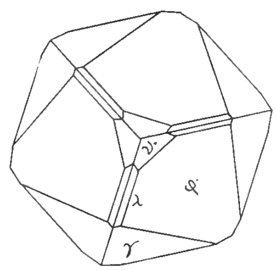

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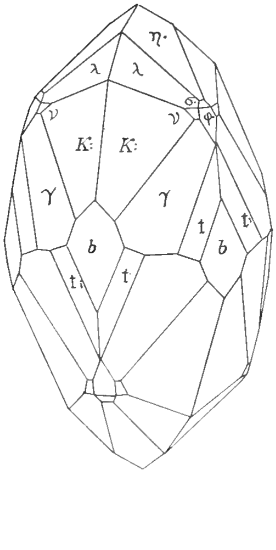
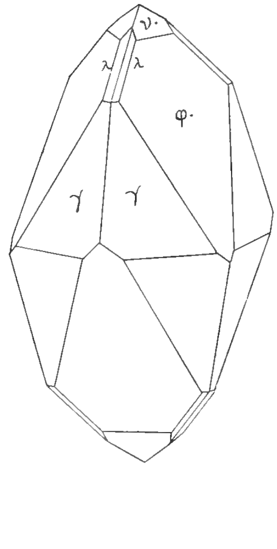




H. P. W. del.

PLATE 11

Calcite from Lyon Mountain, Clinton co.

Page 83

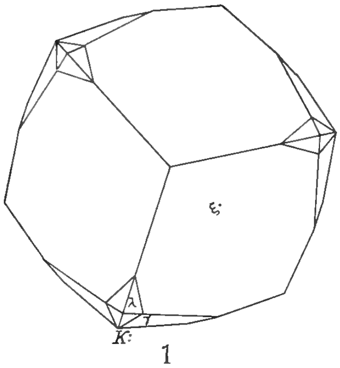
1 Type IV. Rhombohedral habit. Orthographic and clinographic projections. Forms: λ $(22\bar{4}3)$, γ $(8.8.\overline{16}.3)$, $\xi.$ $(04\bar{4}3)$ and K: $(21\bar{3}1)$

2 Type IV. Rhombohedral-pyramidal habit. Individual crystal of composite group shown in figure 3. Forms: π $(11\bar{2}3)$, λ $(22\bar{4}3)$, γ $(8.8.\overline{16}.3)$, $\xi.$ $(04\bar{4}3)$, U: $(54\bar{9}1)$, q: $(24\bar{6}1)$ and 𝔘 $(14.12.\overline{26}.5)$

3 Type IV. Composite crystal showing individuals of figure 2, superposed in parallel position upon p. $(10\bar{1}1)$. Orthographic and clinographic projections

4 Type V. Orthographic and clinographic projections. Forms: λ $(22\bar{4}3)$, α $(44\bar{8}3)$, $\eta.$ $(04\bar{4}5)$, $\xi.$ $(04\bar{4}3)$, $\varphi.$ $(02\bar{2}1)$, $\Delta.$ $(07\bar{7}2)$, $\Sigma.$ $(0.11.\overline{11}.1)$, K: $(21\bar{3}1)$, q: $(24\bar{6}1)$, 𝔎: $(8.4.\overline{12}.1)$ and c: $(34\bar{7}2)$

CALCITES



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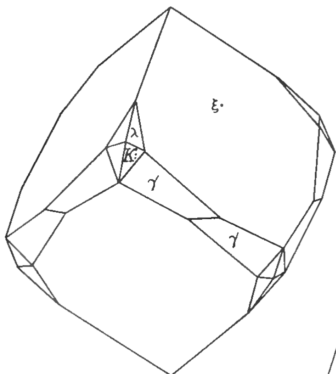

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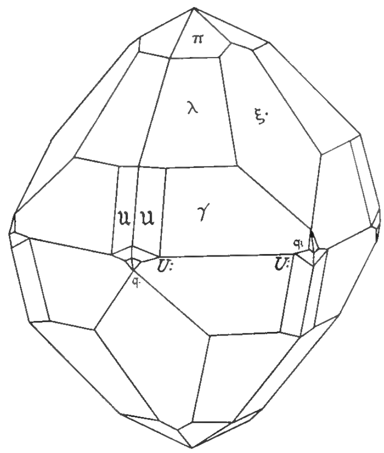

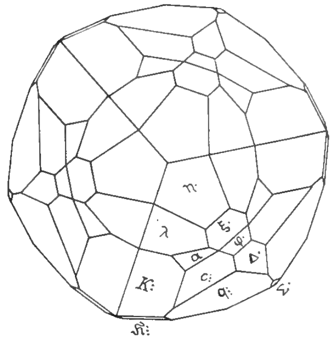

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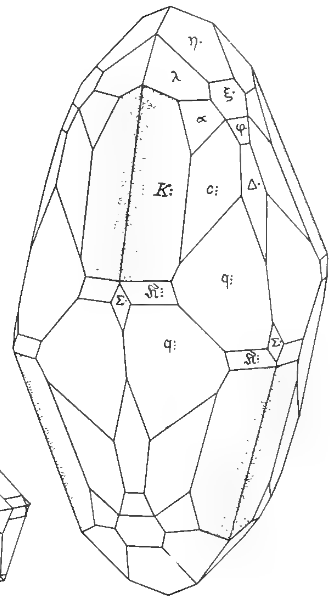

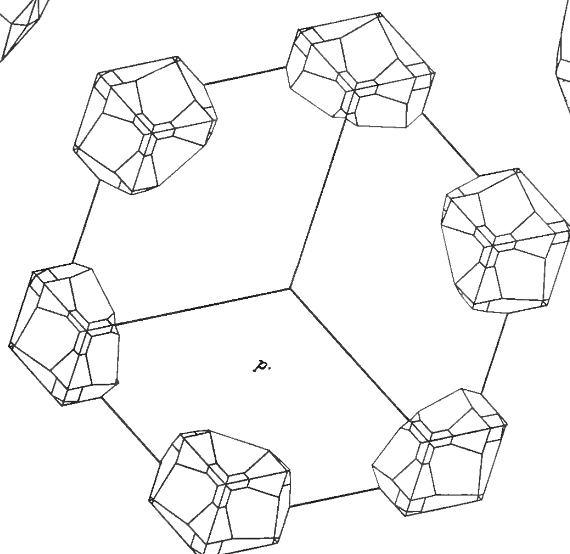

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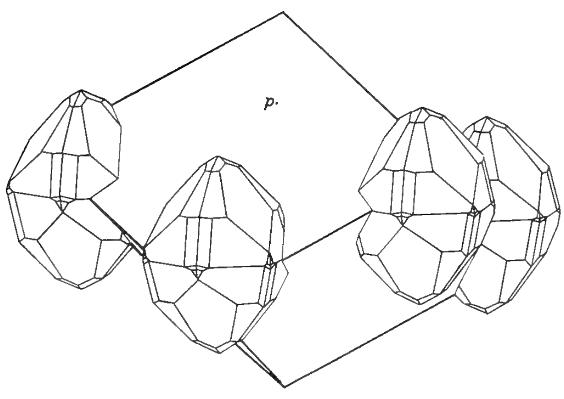
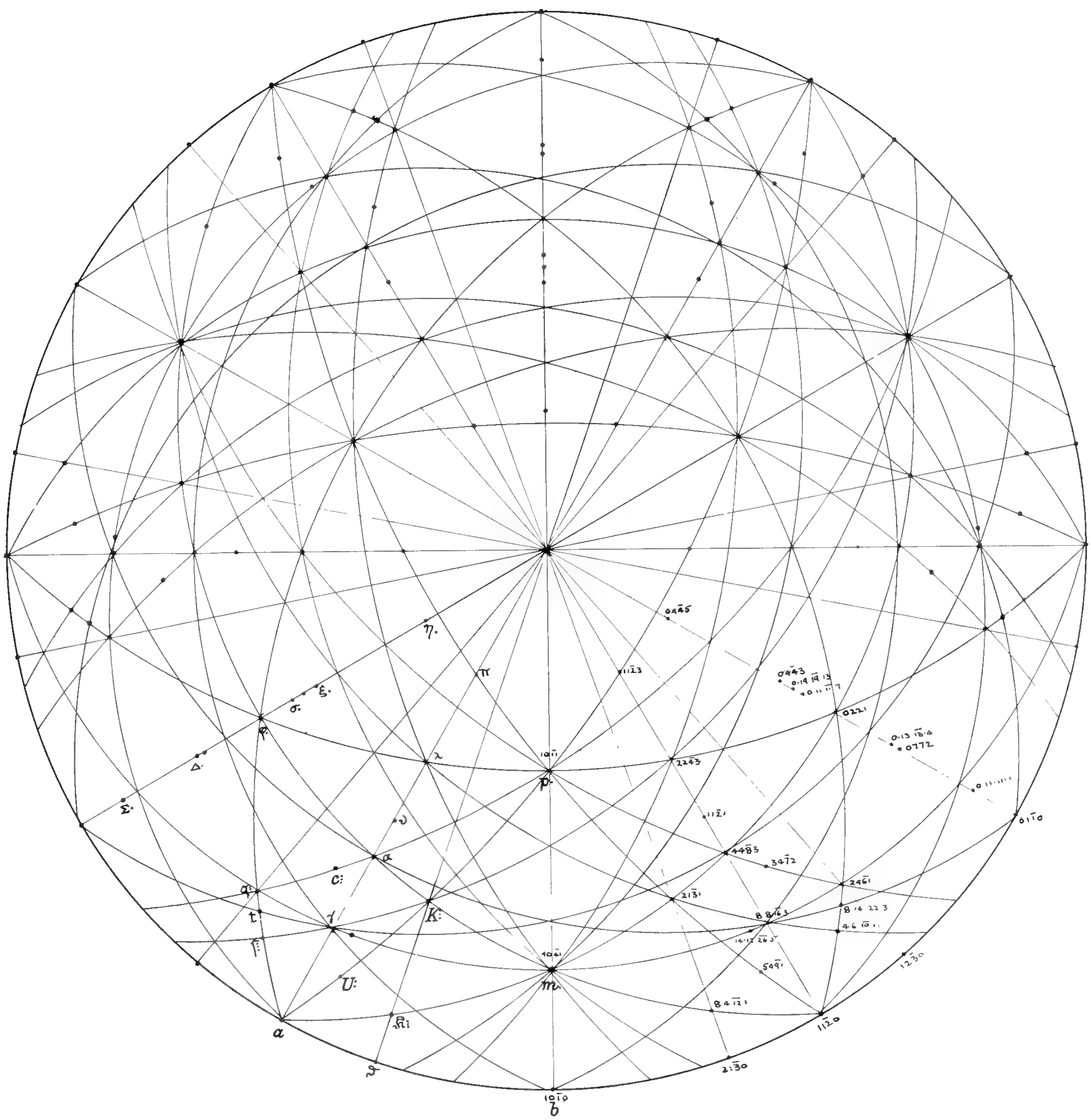


H. P. W. del.

PLATE 12

Stereographic projection of forms occurring on calcite from Lyon Mountain, Clinton co.



H. P. W. del.

PLATE 13

Calcite from Arnold Hill, Clinton co.

Page 91

1 Type I. Prismatic habit. Forms: a $(11\bar{2}0)$, b. $(10\bar{1}0)$, ẟ. $(01\bar{1}2)$ and r: $(29.19.\overline{48}.10)$

2 Type I. Rhombohedral habit. Forms: a $(11\bar{2}0)$, ẟ. $(01\bar{1}2)$, r: $(29.19.\overline{48}.10)$ and 𝔭: $(13\bar{4}1)$

3 Type II. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, ẟ. $(01\bar{1}2)$ and e: $(9.11.\overline{20}.4)$

3a Enlarged individual of scalenohedral habit incrusting the planes of ẟ of crystal shown in figure 3

4 Type III. Forms: o (0001), a $(11\bar{2}0)$ and T: $(43\bar{7}1)$

Calcite from Mineville, Essex co.

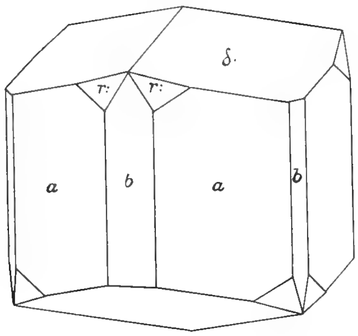
Page 94

5 Phase common to larger crystals. Forms: p. $(10\bar{1}1)$, φ: $(02\bar{2}1)$, Π. $(08\bar{8}1)$ and V: $(6.5.\overline{11}.1)$

6 Phase common to smaller crystals. Forms: φ. $(02\bar{2}1)$, Π. $(08\bar{8}1)$ and V: $(6.5.\overline{11}.1)$

CALCITES

1



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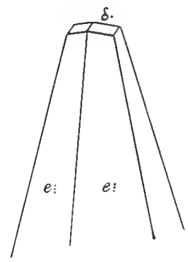

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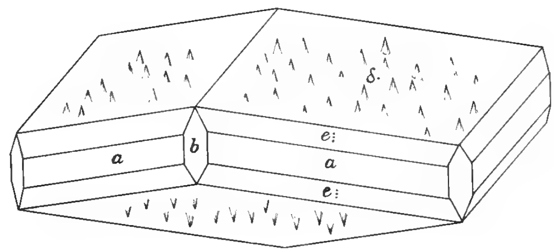

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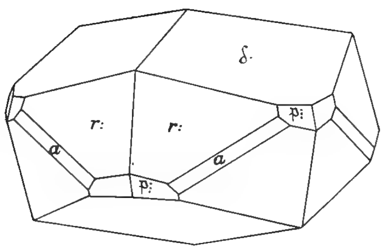

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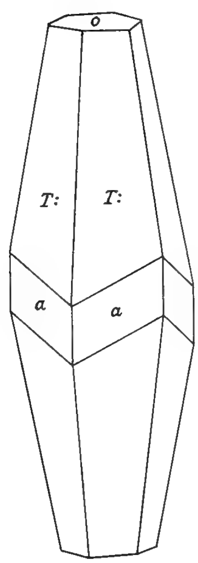

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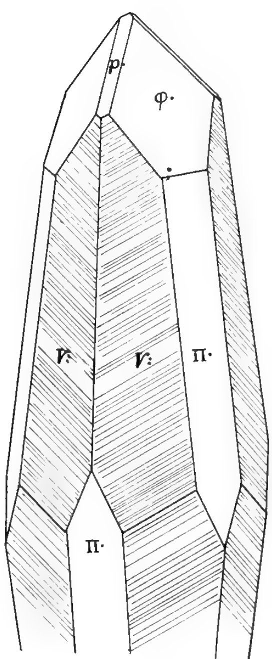

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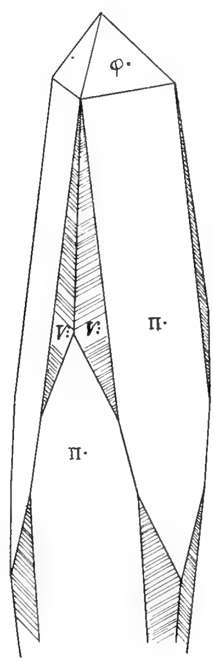


H. P. W. del.

PLATE 14

Calcite from Chilson Lake, Essex co.

Page 95

1 Type I. Crystal of first phase. Forms: o(0001) and $\rho.(03\bar{3}2)$

2 Type I. Composite crystal of first and second phase. Forms: o(0001), $\rho.(03\bar{3}2)$ and $\varphi.(02\bar{2}1)$

3 Type I. Crystal of second phase. Forms: o(0001) and $\varphi.(02\bar{2}1)$

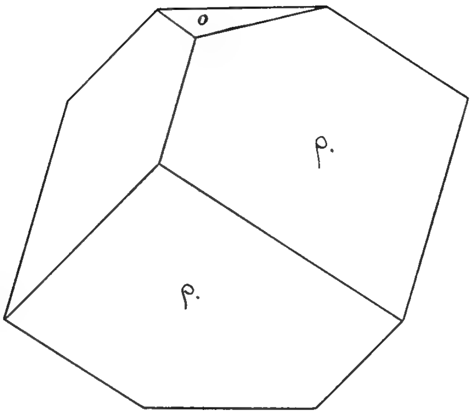
4 Type II. Forms: b $(10\bar{1}0)$, $\varkappa.(01\bar{1}1)$, $\varphi.(02\bar{2}1)$, N: $(53\bar{8}2)$ and $\mathfrak{v}$: $(2.8.\overline{10}.3)$

Calcite from Crown Point, Essex co.

Page 97

5 Twin crystals showing low projecting planes of twinned rhombohedron

1



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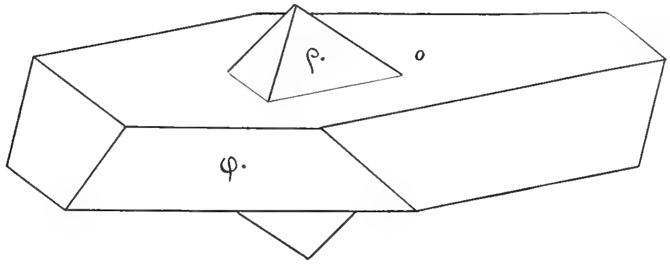

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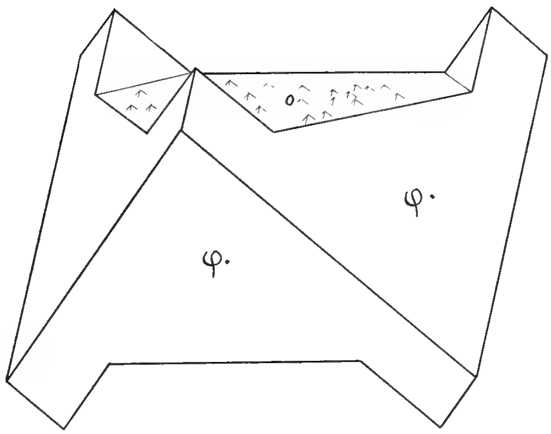

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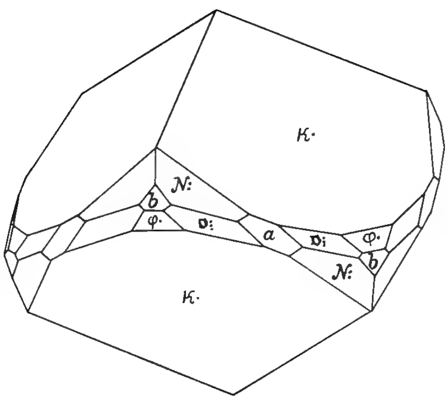

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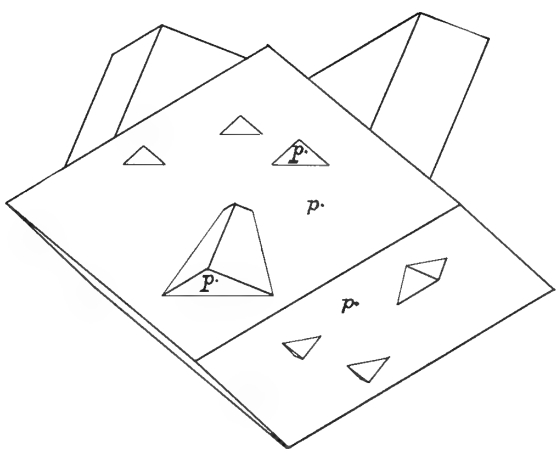


H. P. W. del.

PLATE 15

Calcite from Smith's Basin, Washington co.

Page 95

1 Type I. Forms: δ. $(01\bar{1}2)$ and ι: $(17.15.\overline{32}.2)$

2 Type II. Prismatic habit. Forms: a $(11\bar{2}0)$, μ $(53\bar{8}0)$, p. $(10\bar{1}1)$, φ. $(02\bar{2}1)$, ψ. $(05\bar{5}2)$, Ξ. $(05\bar{5}1)$ and ω: $(15.13.\overline{28}.2)$

3 Type II. Rhombohedral-scalenohedral habit. Forms: p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, φ. $(02\bar{2}1)$, ψ. $(05\bar{5}2)$, θ: $(9.7.\overline{16}.2)$ and r: $(35\bar{8}1)$

4 Type III. Forms: b $(10\bar{1}0)$, φ. $(02\bar{2}1)$, P: $(32\bar{5}1)$, r: $(35\bar{8}1)$ and ℜ: $(8.4.\overline{12}.1)$

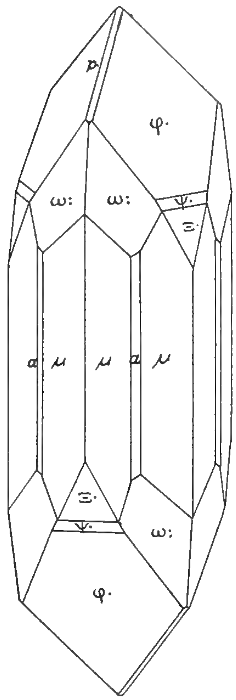
5 Type IV. Prismatic-rhombohedral habit. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, M: $(7.4.\overline{11}.3)$, 𝔭: $(13\bar{4}1)$ and ℜ: $(8.4.\overline{12}.1)$

6 Type IV. Rhombohedral habit. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, Σ. $(0.11.\overline{11}.1)$, M: $(7.4.\overline{11}.3)$ and P: $(32\bar{5}1)$

CALCITES

1

2



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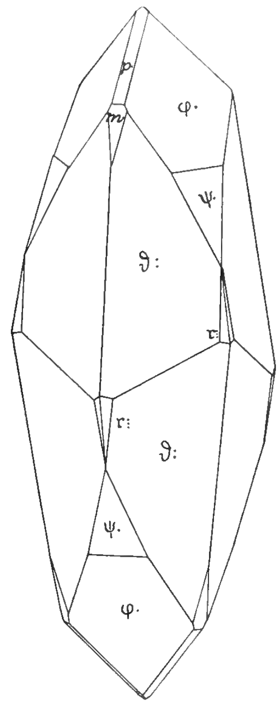

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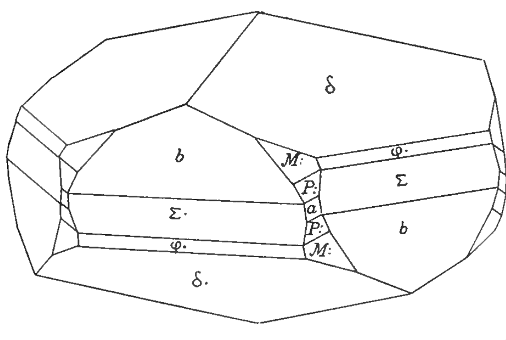

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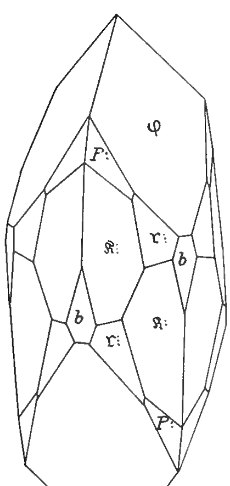

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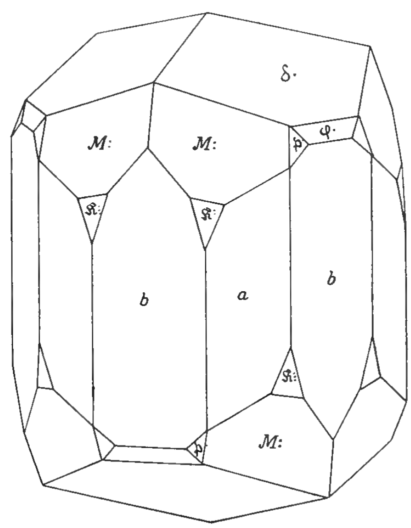
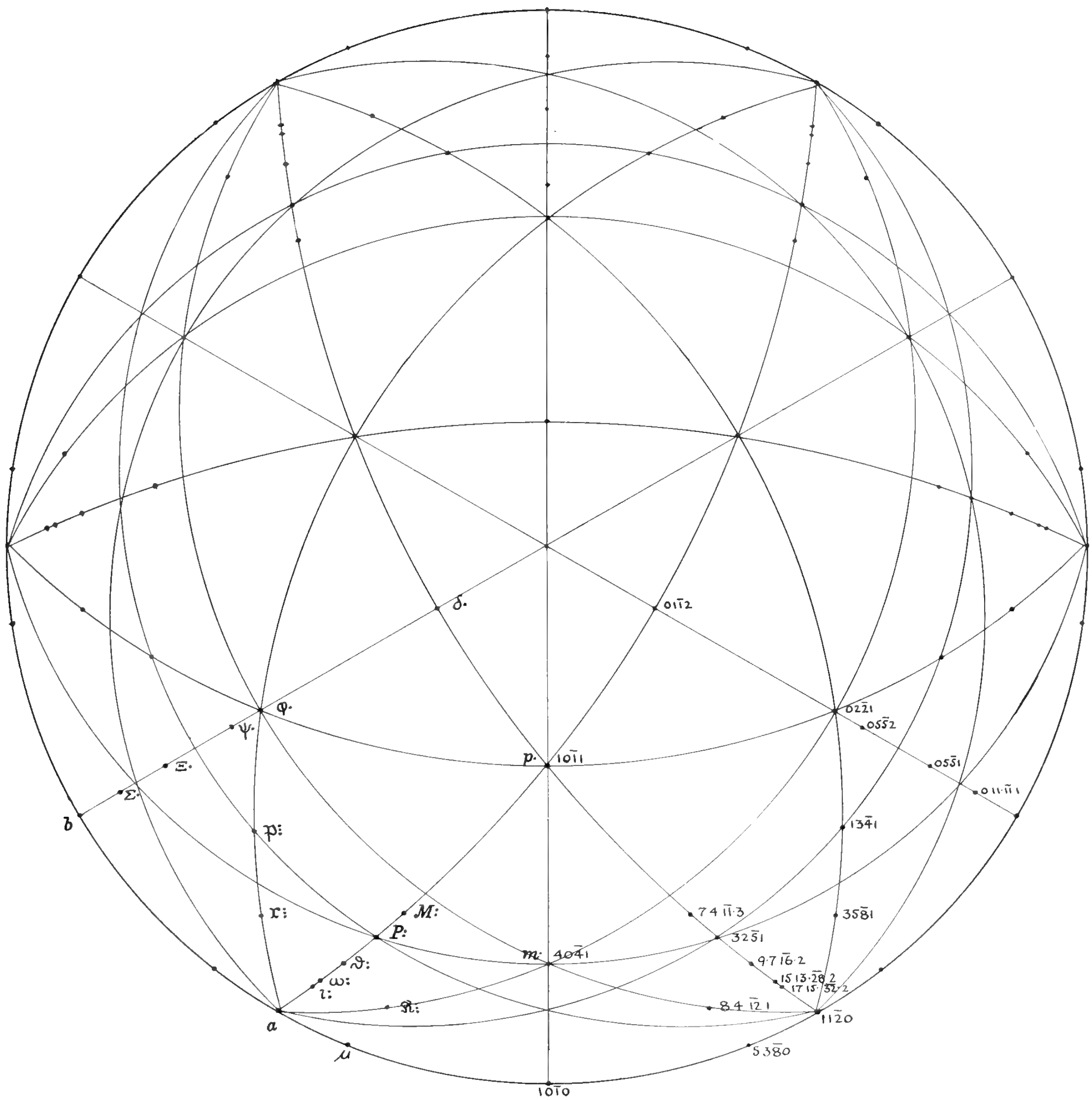


H. P. W. del.

PLATE 16

Stereographic projection of forms occurring on calcite from Smith's Basin, Washington co.

CALCITES



H. P. W. del.

PLATE 17

Calcite from Glens Falls, Warren co.

Page 101

1 Crystal of rhombohedral habit. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, ς $(31\bar{4}0)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, s. $(13.0.\overline{13}.1)$, δ. $(01\bar{1}2)$ and N: $(53\bar{8}2)$

2 Crystal shown in figure 1 twinned parallel to δ. $(01\bar{1}2)$. The crystal is projected with its composition plane vertical and perpendicular to axis II. Forms as above

Calcite from Saratoga, Saratoga co.

Page 103

3 Type I. Rhombohedral-pyramidal habit. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, α $(44\bar{8}3)$, γ $(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, K: $(21\bar{3}1)$ and χ: $(29.17.\overline{46}.12)$

4 Type II. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, δ. $(01\bar{1}2)$ and χ: $(29.17.\overline{46}.12)$

Calcite from Fayetteville, Onondaga co.

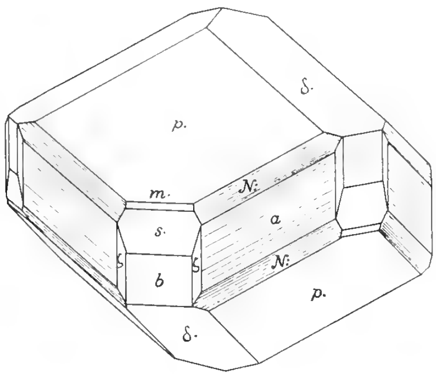
Page 104

5 Forms: p. $(10\bar{1}1)$ and K: $(21\bar{3}1)$

6 Forms: a $(11\bar{2}0)$, γ $(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, K: $(21\bar{3}1)$ and 𝔅: $(2.9.\overline{11}.5)$

CALCITES

1



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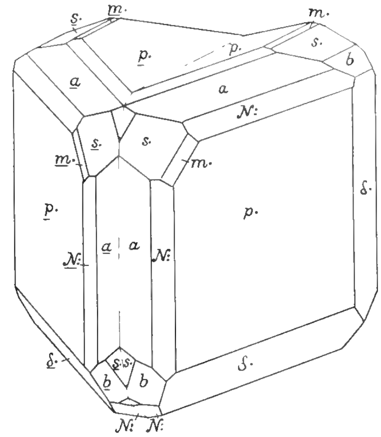

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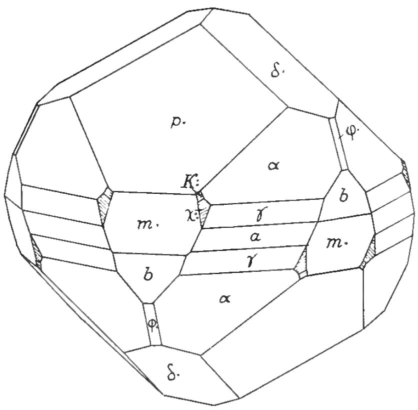

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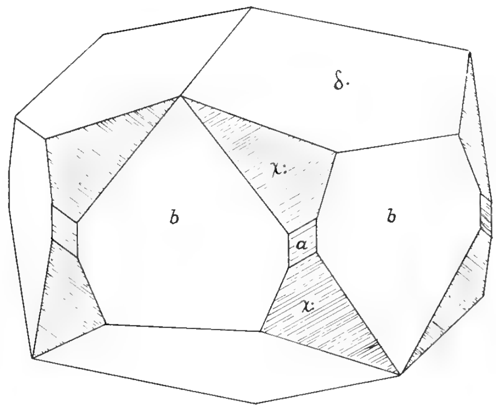

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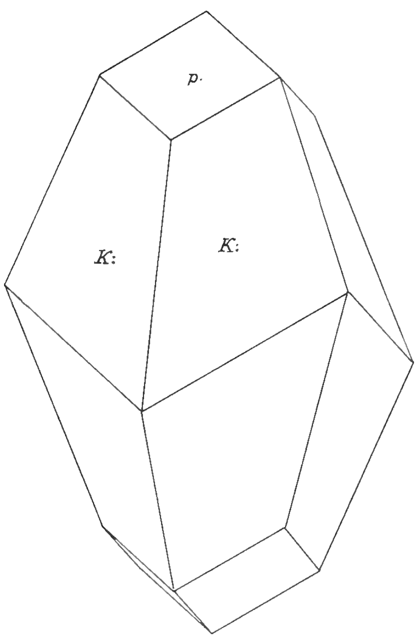

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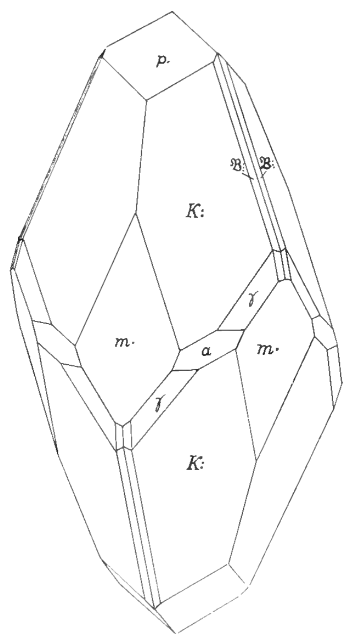


H. P. W. del.

PLATE 18

Calcite from Union Springs, Cayuga co.

Page 105

1 Type I. First generation. Forms: $\gamma\,(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$ and $\delta.\,(01\bar{1}2)$

2 Type II. First generation. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, $\gamma\,(8.8.\overline{16}.3)$, m. $(40\bar{4}1)$, K: $(21\bar{3}1)$, M: $(7.4.\overline{11}.3)$ and $\Theta\,(12\bar{3}1)$

3 Type II. First generation. Forms: b $(10\bar{1}0)$, $\gamma\,(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, s. $(13.0.\overline{13}.1)$ and K: $(21\bar{3}1)$

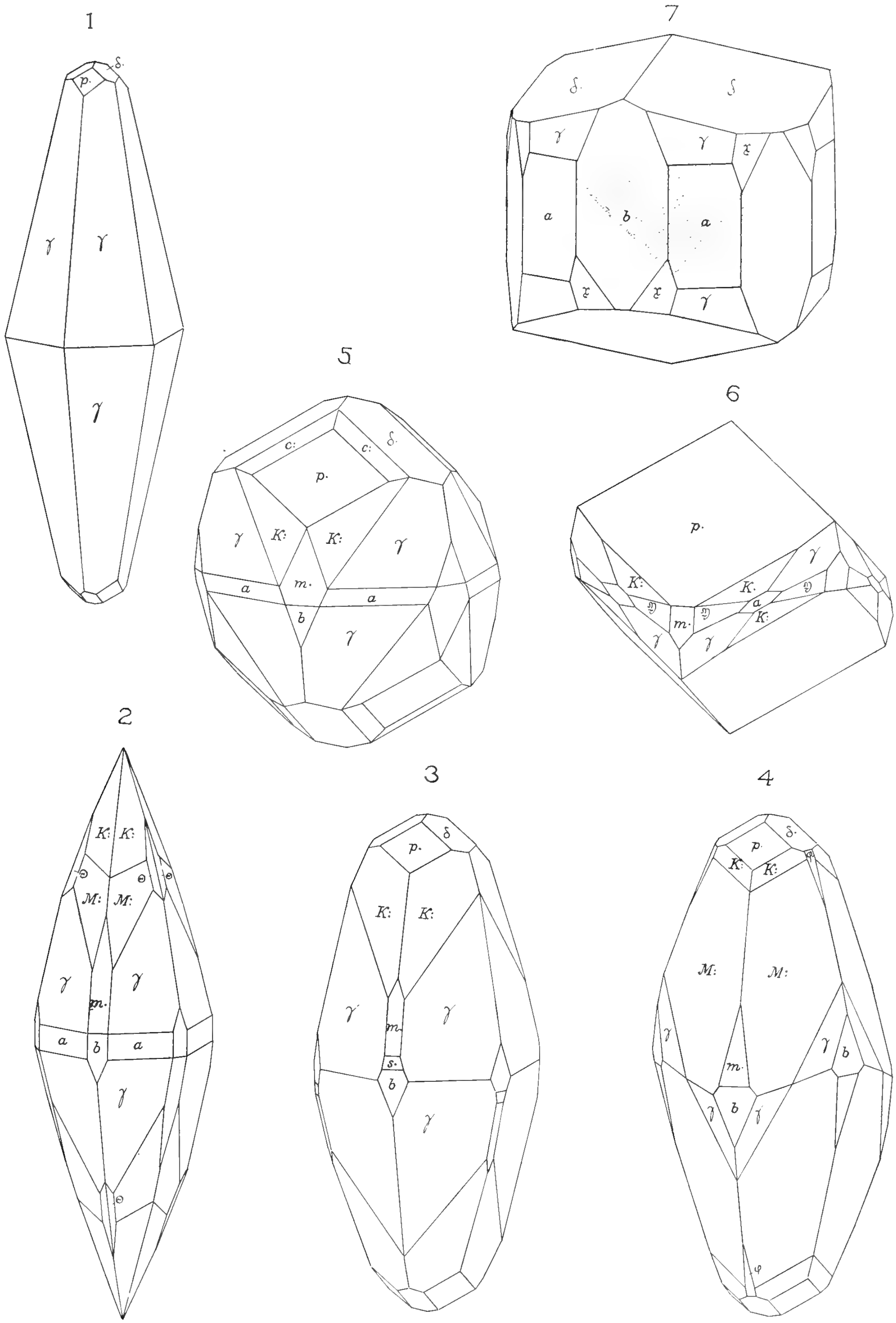
4 Type II. First generation. Forms: b $(10\bar{1}0)$, $\gamma\,(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, $\delta.\,(01\bar{1}2)$, $\varphi.\,(02\bar{2}1)$, K: $(21\bar{3}1)$ and M: $(7.4.\overline{11}.3)$

5 Type III. First generation. Rhombohedral-pyramidal habit. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, $\gamma\,(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, $\delta.\,(01\bar{1}2)$, c: $(61\bar{7}8)$ and K: $(21\bar{3}1)$

6 Type III. First generation. Rhombohedral habit. Forms: a $(11\bar{2}0)$, $\gamma\,(8.8.\overline{16}.3)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, K: $(21\bar{3}1)$ and $\mathfrak{Y}$: $(19.10.\overline{29}.6)$

7 Type IV. Second generation. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, $\gamma\,(8.8.\overline{16}.3)$, $\delta.\,(01\bar{1}2)$ and $\mathfrak{x}\,(3.15.\overline{18}.2)$

CALCITES



H. P. W. del.

PLATE 19

Calcite from Union Springs, Cayuga co.

Page 108

1 Scalenohedron of the form M: $(7.4.\overline{11}.3)$ showing the position of the twinning planes of the twin crystals of type V

2 Type V. Second generation. Crystal twinned parallel to o (0001). Forms: b $(10\overline{1}0)$, γ $(8.8.\overline{16}.3)$ and M: $(7.4.\overline{11}.3)$

3 Type V. Second generation. Crystal twinned parallel to δ. $(01\overline{1}2)$. The crystal is projected with its composition plane vertical and perpendicular to the axis II. Forms: b $(10\overline{1}0)$, γ $(8.8.\overline{16}.3)$ and M: $(7.4.\overline{11}.3)$

3a Position of the cleavage plane p. on the above twin crystal

4 Type V. Second generation. Crystal twinned parallel to φ. $(02\overline{2}1)$. The crystal is projected with its composition plane vertical and perpendicular to the axis II. Form: M: $(7.4.\overline{11}.3)$

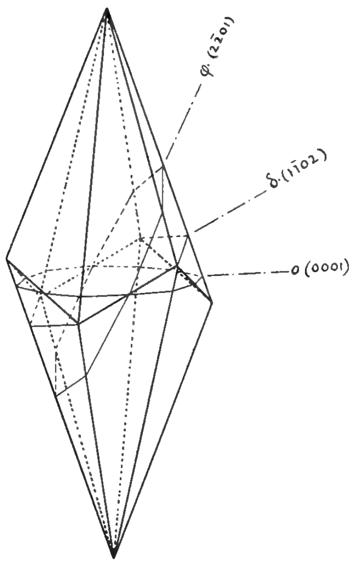
4a Position of the cleavage plane p. on the above crystal

5 Type VI. Second generation. Forms: b $(10\overline{1}0)$, γ $(8.8.\overline{16}.3)$, p. $(10\overline{1}1)$, m. $(40\overline{4}1)$, δ. $(01\overline{1}2)$, M: $(7.4.\overline{11}.3)$ and $\mathfrak{Y}$: $(19.10.\overline{29}.6)$

6 Type VI. Second generation. Combination of figure 5 twinned parallel to o (0001)

7 Type VII. Second generation. Penetration twin. Forms: a $(11\overline{2}0)$, p. $(10\overline{1}1)$, m. $(40\overline{4}1)$ and δ. $(01\overline{1}2)$

1



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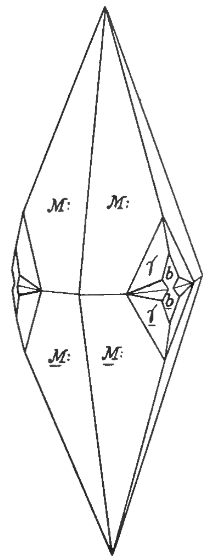
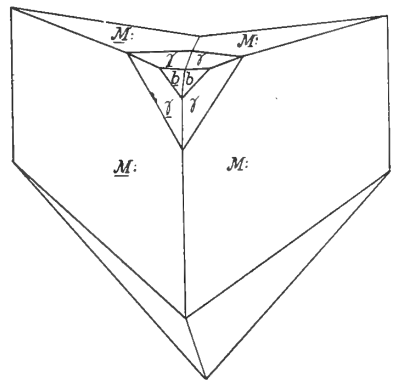


3a

3



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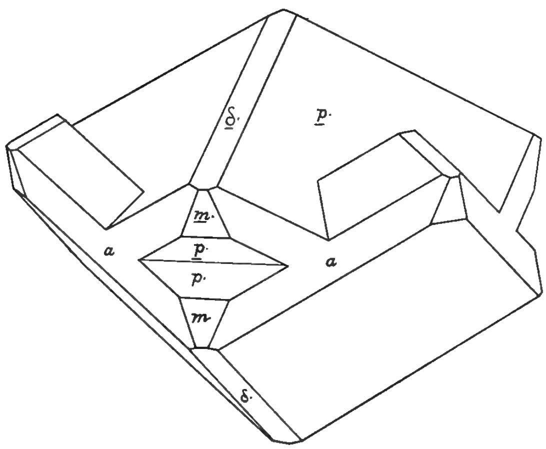

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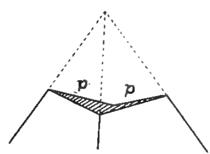

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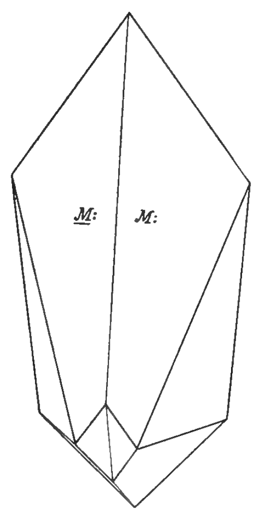

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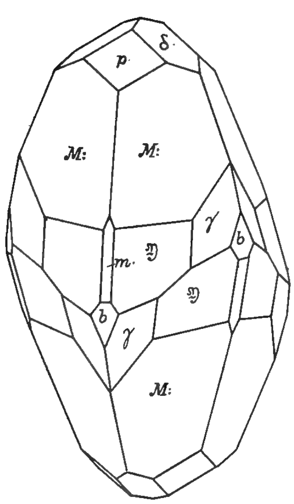

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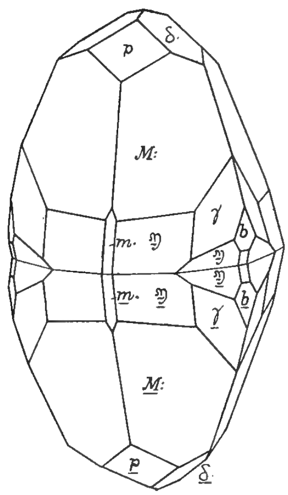
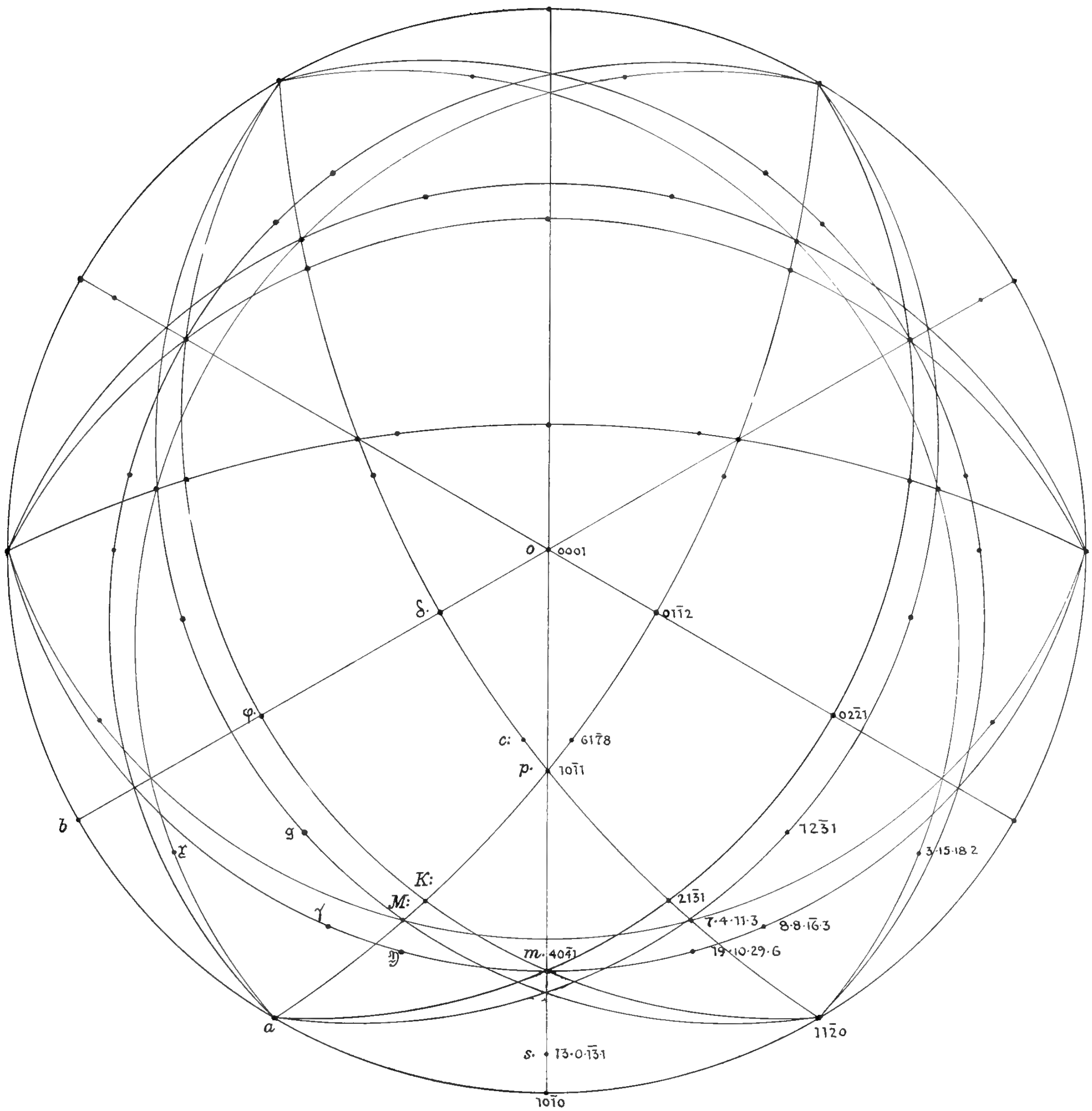


H. P. W. del.

PLATE 20

Stereographic projection of forms occurring on calcite from Union Springs, Cayuga co.



o 0001
δ
01$\bar{1}$2
φ
02$\bar{2}$1
c
61$\bar{7}$8
p
10$\bar{1}$1
b
g
$\bar{1}$2$\bar{3}$1
r
3.15.$\bar{18}$.2
K
M
21$\bar{3}$1
γ
7.4.$\bar{11}$.3
8.8.$\bar{16}$.3
m 40$\bar{4}$1
19.10.$\bar{29}$.6
a
11$\bar{2}$0
s 13.0.$\bar{13}$.1
10$\bar{1}$0

H. P. W. del.

PLATE 21

Calcite from Howes Cave, Schoharie co.

Page 111

1 Type I. Forms: p. $(10\bar{1}1)$, q. $(70\bar{7}1)$, δ. $(01\bar{1}2)$, K: $(21\bar{3}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

2 Type II. Forms: m. $(40\bar{4}1)$, q. $(70\bar{7}1)$, δ. $(01\bar{1}2)$, b: $(71\bar{8}9)$, K: $(21\bar{3}1)$, U: $(10.4.\bar{14}.3)$, $\mathfrak{J}$: $(62\bar{8}1)$ and $\mathfrak{H}$ $(9.4.\bar{13}.2)$

3 Type II. Forms: b $(10\bar{1}0)$, m. $(40\bar{4}1)$, q. $(70\bar{7}1)$, δ. $(01\bar{1}2)$, Φ. $(0.14.\bar{14}.1)$, b: $(71\bar{8}9)$, K: $(21\bar{3}1)$, U: $(10.4.\bar{14}.3)$, $\mathfrak{J}$: $(62\bar{8}1)$, $\mathfrak{R}$: $(8.4.\bar{12}.1)$, T $(42\bar{6}1)$ and $\mathfrak{H}$ $(9.4.\bar{13}.2)$. An undetermined scalenohedron is indicated by ?

4 Type II. Forms: m. $(40\bar{4}1)$, q. $(70\bar{7}1)$, δ. $(01\bar{1}2)$, Φ. $(0.14.\bar{14}.1)$, b: $(71\bar{8}9)$, K: $(21\bar{3}1)$, $\mathfrak{p}$: $(13\bar{4}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$. An undetermined negative scalenohedron is indicated by ?

5 Type II. Penetration twin. Forms: p. $(10\bar{1}1)$, q. $(70\bar{7}1)$, b: $(71\bar{8}9)$, K: $(21\bar{3}1)$ and $\mathfrak{J}$: $(62\bar{8}1)$

6 Type III. Forms: a $(11\bar{2}0)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, e: $(41\bar{5}6)$, H: $(31\bar{4}2)$ and K: $(21\bar{3}1)$

CALCITES

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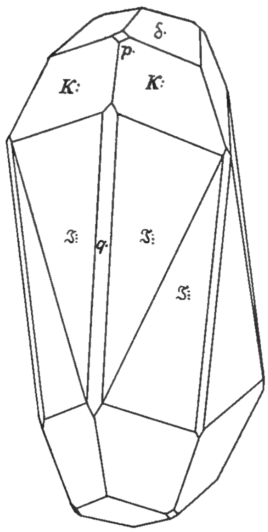

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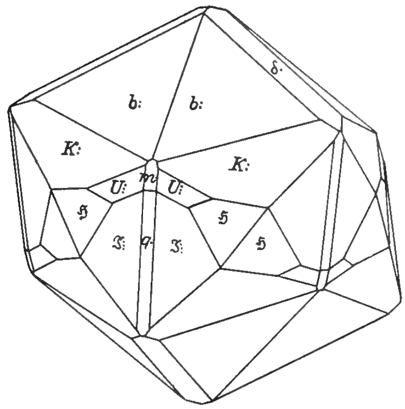

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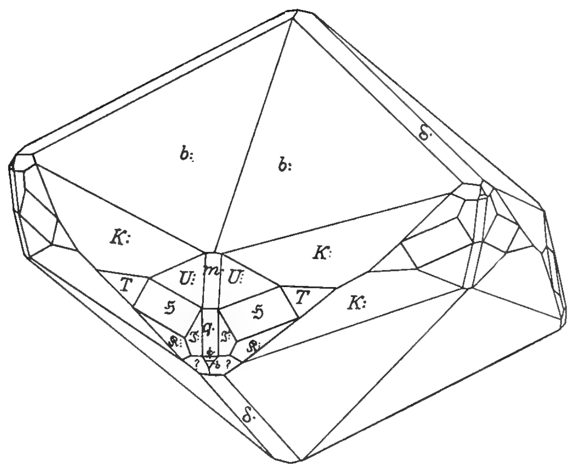

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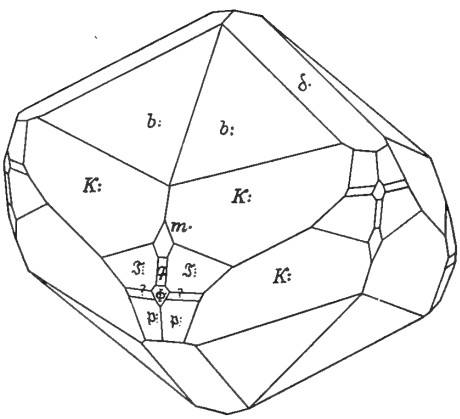

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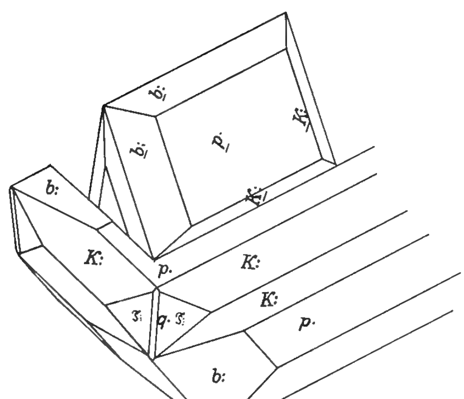

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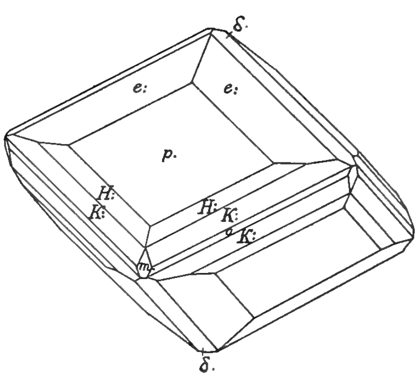
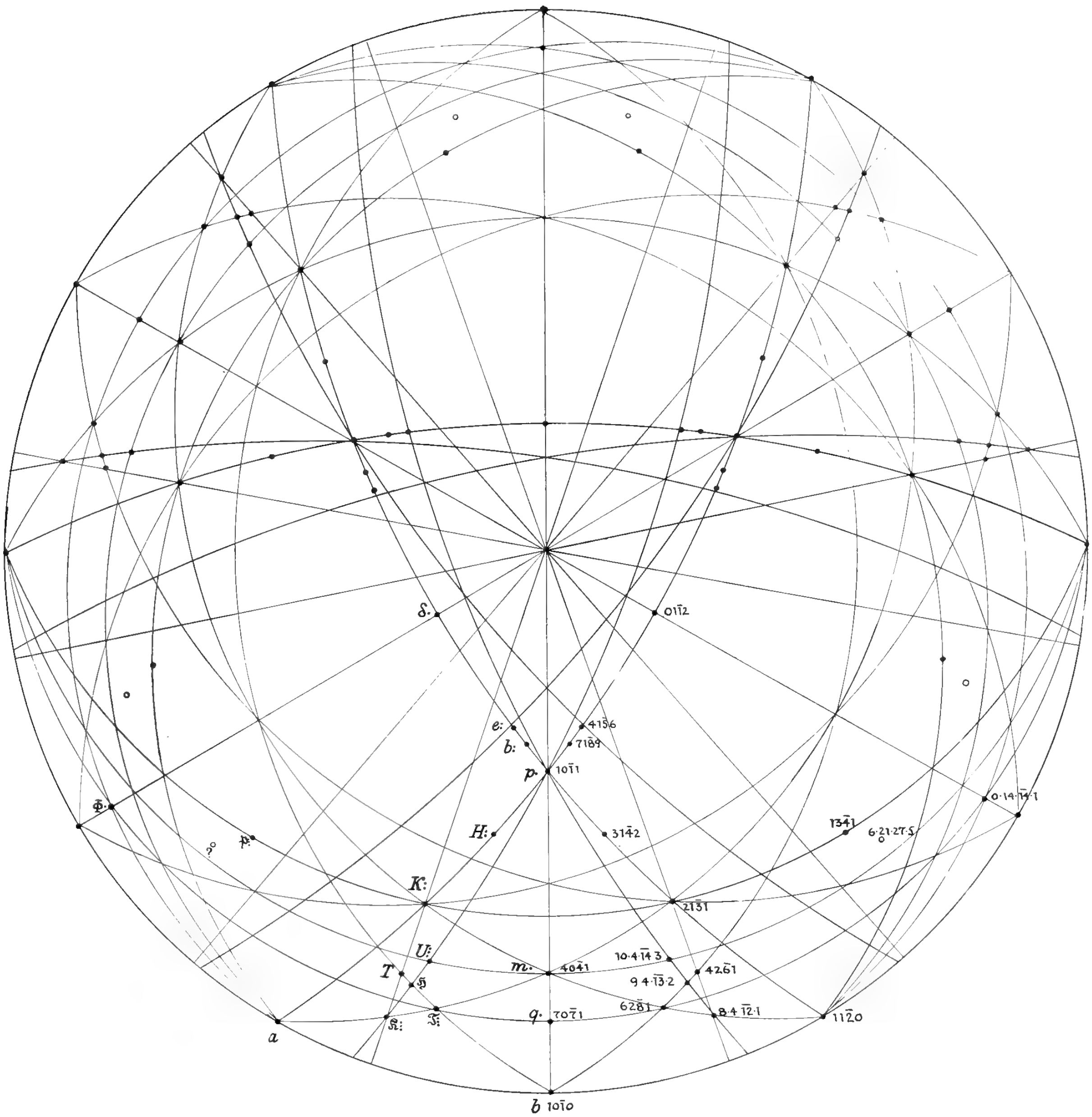


H. P. W. del.

PLATE 22

Stereographic projection of forms occurring on calcite from Howes Cave, Schoharie co.

CALCITES



H. P. W. del.

PLATE 23

Calcite from South Bethlehem, Albany co.

Page 115

1 Type I. Forms: b $(10\bar{1}0)$, p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, q. $(70\bar{7}1)$, K: $(21\bar{3}1)$ and 𝔍: $(62\bar{8}1)$

2 Type I. Forms: b $(10\bar{1}0)$, m. $(40\bar{4}1)$, s. $(13.0.\overline{13}.1)$, δ. $(01\bar{1}2)$, K: $(21\bar{3}1)$ and 𝔍: $(62\bar{8}1)$

3 Type II. Forms: p. $(10\bar{1}1)$, m. $(40\bar{4}1)$, δ. $(01\bar{1}2)$, x: $(4.3.\bar{7}.10)$, G: $(72\bar{9}5)$ and K: $(21\bar{3}1)$

4 Type III. Forms: b $(10\bar{1}0)$, p. $(10\bar{1}1)$, δ. $(01\bar{1}2)$, η. $(04\bar{4}5)$, θ. $(07\bar{7}8)$, x: $(4.3.\bar{7}.10)$ and K: $(21\bar{3}1)$

Calcite from New Baltimore, Greene co.

Page 117

5 Crystal of second generation showing phantom of graphite inclusions outlining a crystal of the first generation. Forms: δ. $(01\bar{1}2)$ and K: $(21\bar{3}1)$

6 Crystal of the first generation showing superposed growths of the second generation, the latter containing graphite inclusions. Forms: p. $(10\bar{1}1)$, δ. $(01\bar{1}2)$ and K: $(21\bar{3}1)$

CALCITES

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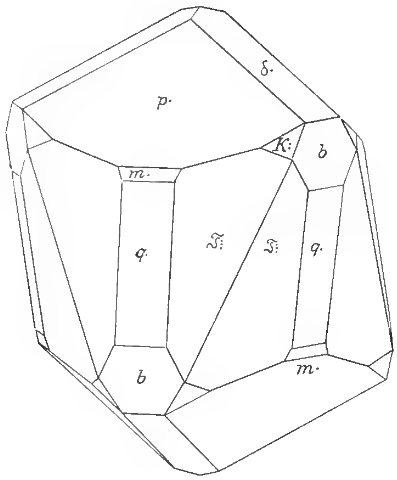

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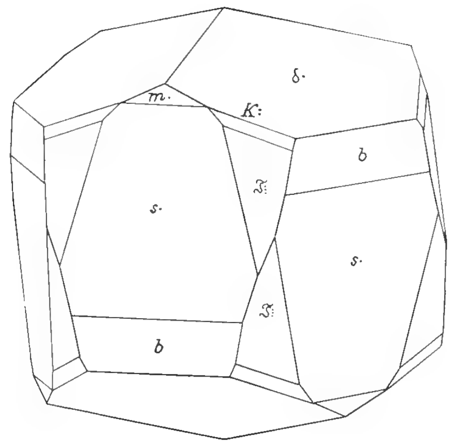

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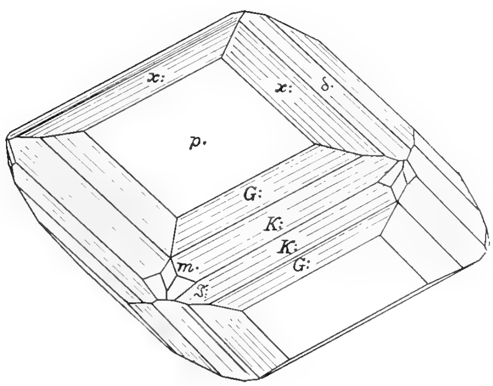

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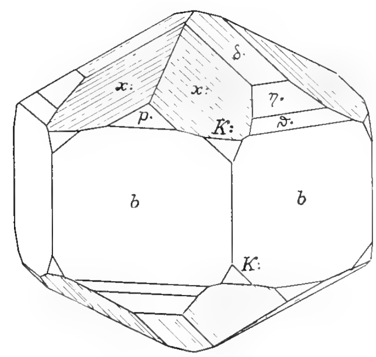

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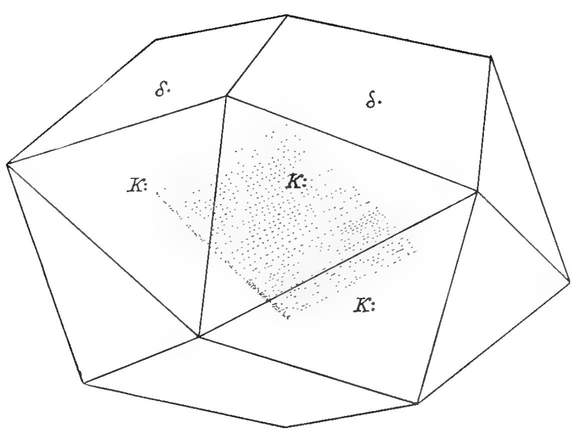

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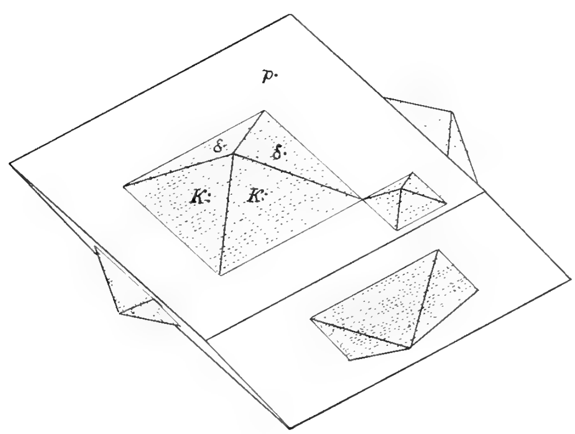


H. P. W. del.

PLATE 24

Calcite from the vicinity of Catskill, Greene co.

Page 117

1 Type I, from Austin's glen, Catskill. Forms: b. $(10\bar{1}0)$, ∂. $(01\bar{1}2)$ and 𝔡 $(10.3.\bar{1}\bar{3}.2)$

2 Type I, from Alsen. Forms: ∂. $(01\bar{1}2)$ and 𝔑: $(11.3.\bar{1}\bar{4}.2)$

3 Type II, from Alsen. Forms: b $(10\bar{1}0)$, ∂. $(01\bar{1}2)$, H: $(31\bar{4}2)$ and N: $(53\bar{8}2)$

4 Type II, from West Camp. Forms: a $(11\bar{2}0)$, b $(10\bar{1}0)$, ∂. $(01\bar{1}2)$ and N: $(53\bar{8}2)$

5 Type III, from Alsen. Forms: b $(10\bar{1}0)$, v: $(7.4.\bar{1}\bar{1}.15)$, G: $(72\bar{9}5)$ and P: $(32\bar{5}1)$

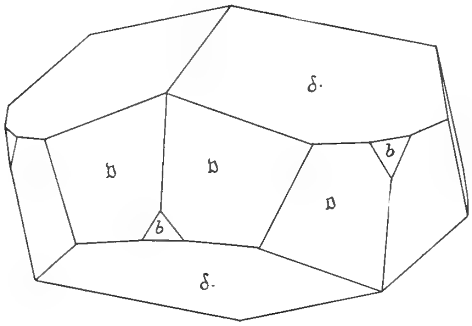
Calcite from Hudson, Columbia co.

Page 119

6 Forms: a $(11\bar{2}0)$, p. $(10\bar{1}1)$ and 𝔐: $(16.4.\bar{2}\bar{0}.3)$

CALCITES

1



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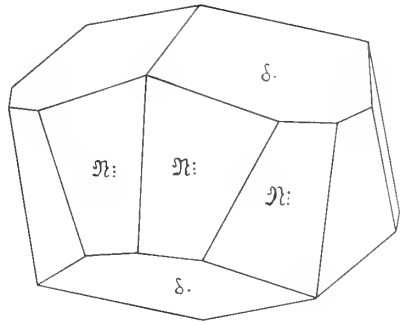

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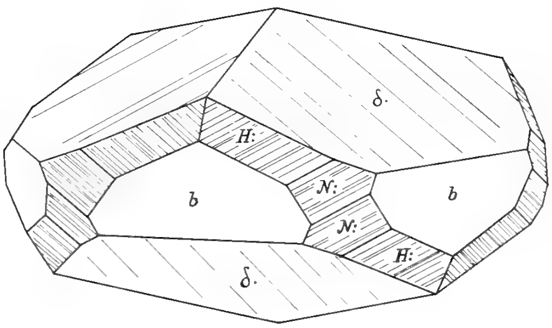

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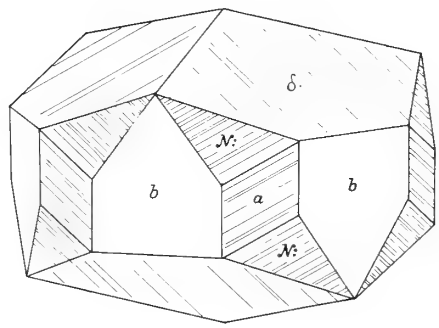

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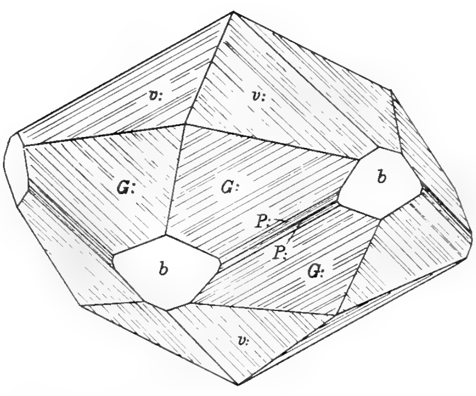

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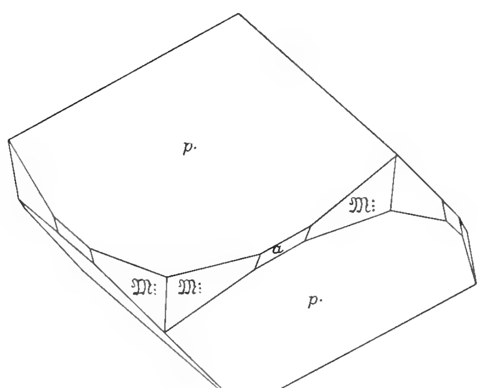

H. P. W. del.

PLATE 2[illegible]

181

Calcite from Rondout, Ulster co.

Page 120

1 Type I. Forms: b $(10\bar{1}0)$ and ẟ. $(01\bar{1}2)$

2 Type II. Scalenohedral habit. Forms: ẟ. $(01\bar{1}2)$ and 𝔇 $(15.4.\bar{19}.3)$

3 Type II. Rhombohedral-scalenohedral habit. Forms: o (0001), a $(11\bar{2}0)$, ẟ. $(01\bar{1}2)$ and 𝔇 $(15.4.\bar{19}.3)$

4 Type II. Rhombohedral-scalenohedral habit. Forms: ẟ. $(01\bar{1}2)$, Δ. $(07\bar{7}2)$ and 𝔇 $(15.4.\bar{19}.3)$

5 Type II. Scalenohedral habit twinned parallel to o (0001). Forms: ẟ. $(01\bar{1}2)$ and 𝔇 $(15.4.\bar{19}.3)$

6 Type II. Scalenohedral habit twinned parallel to ẟ. $(01\bar{1}2)$. The crystal is projected with its composition plane vertical and perpendicular to the axis II. Forms: ẟ. $(01\bar{1}2)$ and 𝔇 $(15.4.\bar{19}.3)$.

CALCITES

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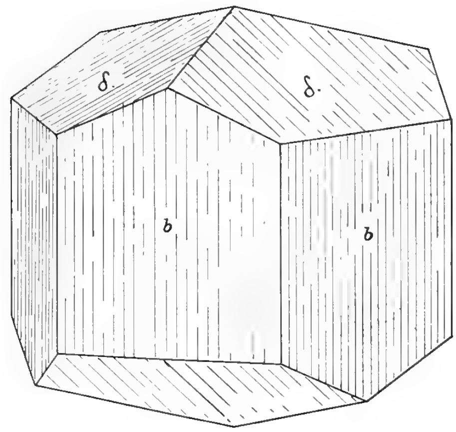

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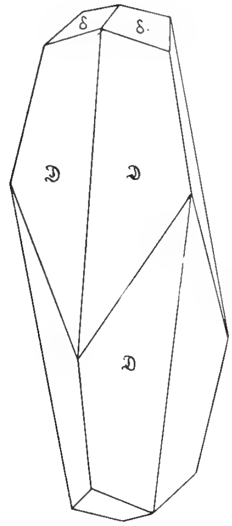

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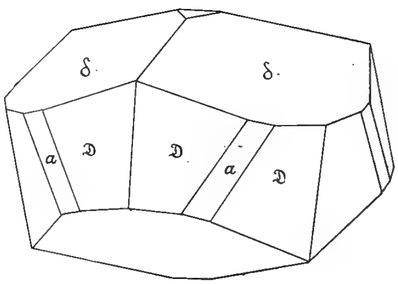

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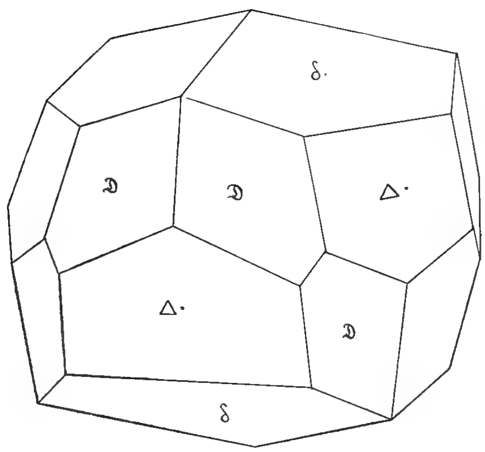

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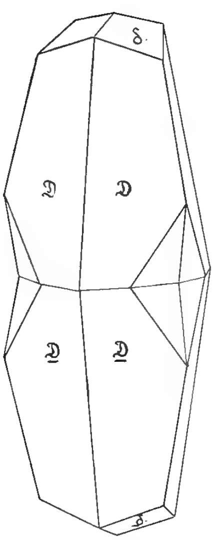

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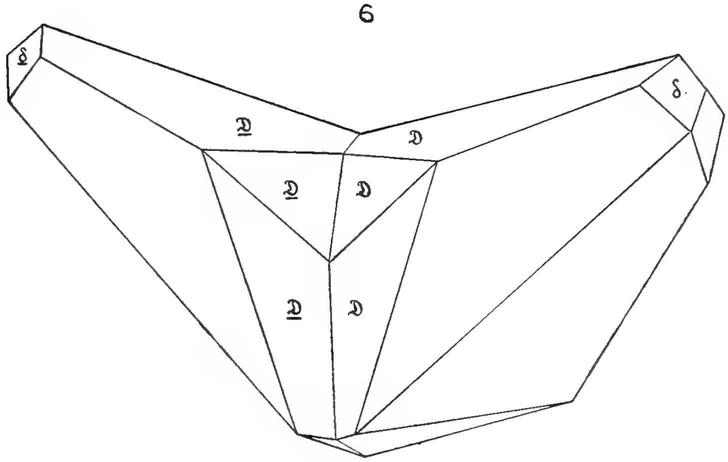

H. P. W. del.

PLATE 26

183

Calcite from Rondout, Ulster co.

Page 121

1 Type III. Forms: a $(11\bar{2}0)$, δ. $(01\bar{1}2)$, $\mathfrak{D}$ $(15.4.\bar{19}.3)$ and $\mathfrak{x}$ $(3.15.\bar{18}.2)$

2 Type III. Forms: a $(11\bar{2}0)$, δ. $(01\bar{1}2)$, $\mathfrak{D}$ $(15.4.\bar{19}.3)$ and $\mathfrak{y}$ $(3.16.\bar{19}.2)$

3 Type III. Forms: a $(11\bar{2}0)$, p. $(10\bar{1}1)$, δ. $(01\bar{1}2)$ and K: $(21\bar{3}1)$

4 Type IV. Forms: δ. $(01\bar{1}2)$, η. $(04\bar{4}5)$ and c. $(0.13.\bar{13}.1)$

5 Type IV. Curved phase of figure 4 resulting from the development of vicinal planes

6 Type V. Rhombohedral habit. Forms: δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, Q. $(07\bar{7}1)$ and Y $(12.32.\bar{44}.13)$

7 Type V. Rhombohedral-scalenohedral habit. Forms: ς $(31\bar{4}0)$, δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, Φ. $(0.14.\bar{14}.1)$, T. $(0.28.\bar{28}.1)$, K: $(21\bar{3}1)$ and Y $(12.32.\bar{44}.13)$

CALCITES

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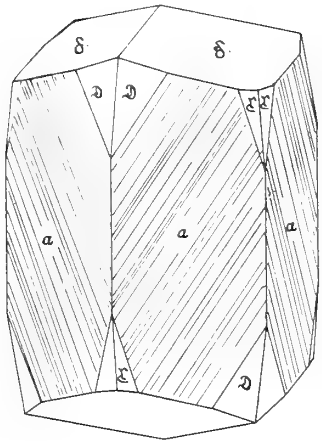

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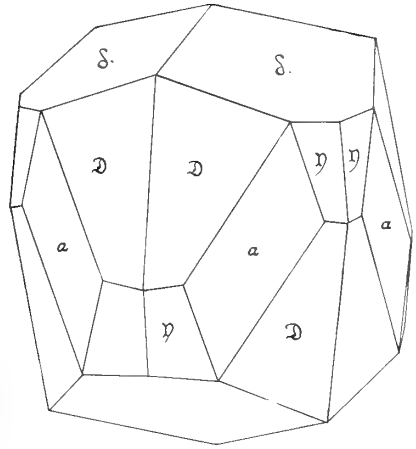

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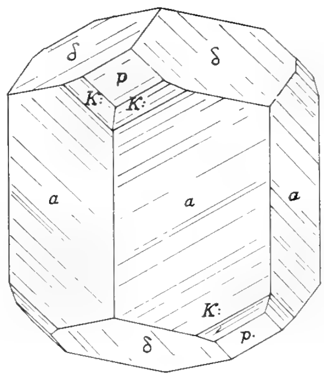

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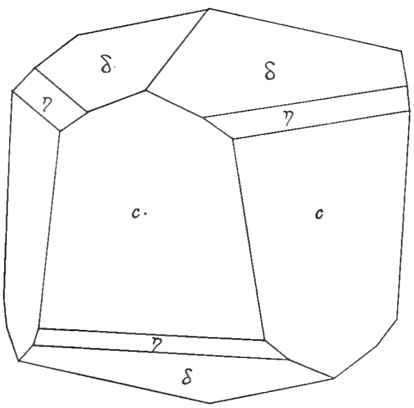

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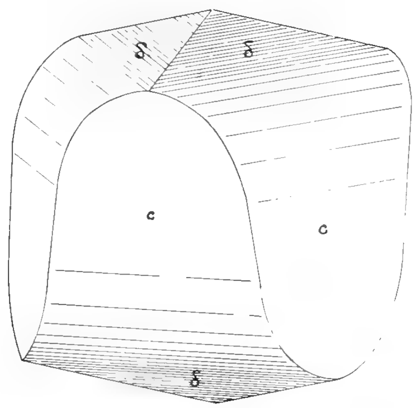

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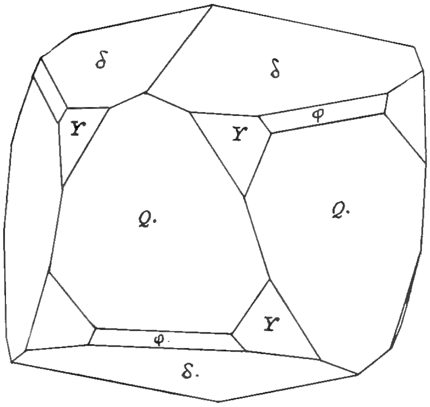

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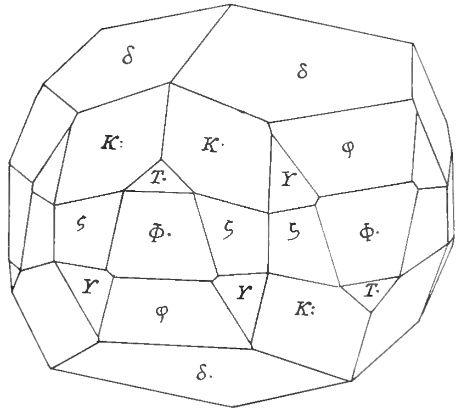

H. P. W. del.

PLATE 27

185

Calcite from Rondout, Ulster co.

Page 123

1 Type VI. Forms: b $(10\bar{1}0)$, p $(10\bar{1}1)$ and F. $(0.12.\bar{12}.5)$

2 Type VI. Built-up crystal. Forms: δ. $(01\bar{1}2)$, φ. $(02\bar{2}1)$, F. $(0.12.\bar{12}.5)$, ω. $(0.11.\bar{11}.4)$ and Ψ. $(0.17.\bar{17}.1)$

2a Section of the above normal to the rhombohedral zone

3 Type VII. Crystal of rhombohedral-scalenohedral habit showing symmetrical disposition of pyrite inclusions. Forms: δ. $(01\bar{1}2)$, H: $(31\bar{4}2)$ and 𝔳 $(10.3.\bar{13}.2)$

4 Type VII. Rhombohedral-scalenohedral habit. Forms: z. $(28.0.\bar{28}.1)$, δ. $(01\bar{1}2)$, L: $(17.9.\bar{26}.8)$ and 𝔳 $(10.3.\bar{13}.2)$

5 Type VIII. Forms: δ. $(01\bar{1}2)$, f: $(7.2.\bar{9}.11)$, D: $(61\bar{7}5)$ and G: $(72\bar{9}5)$

6 Type IX. Forms: a $(11\bar{2}0)$, p. $(10\bar{1}1)$, δ. $(01\bar{1}2)$ and 𝔇 $(15.4.\bar{19}.3)$

CALCITES

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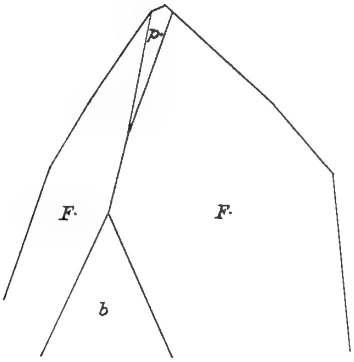

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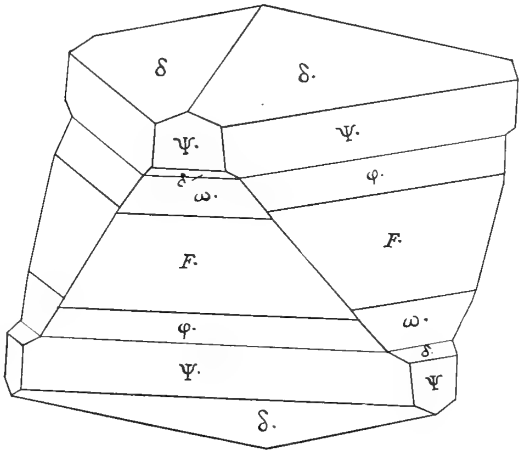

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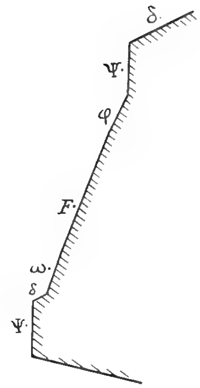

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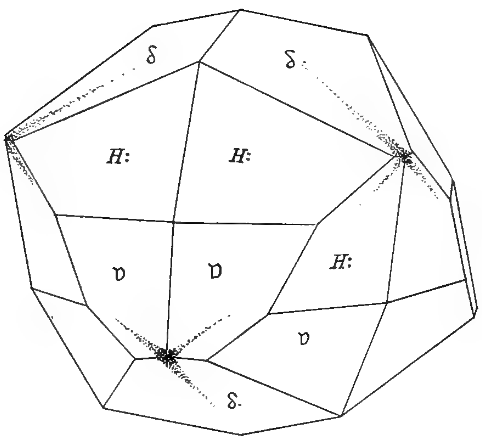

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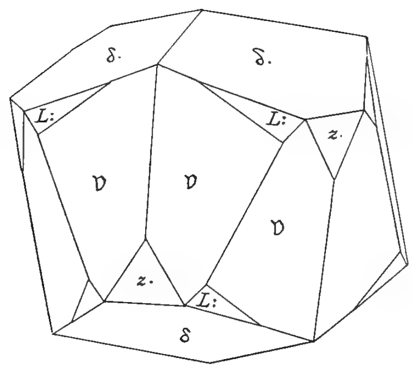

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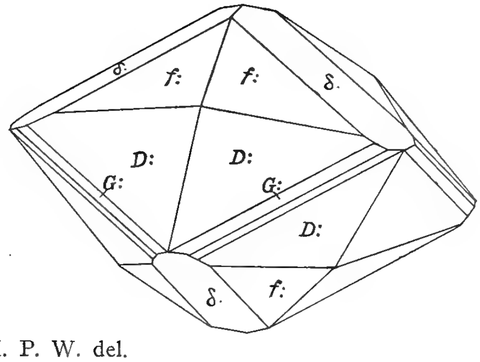

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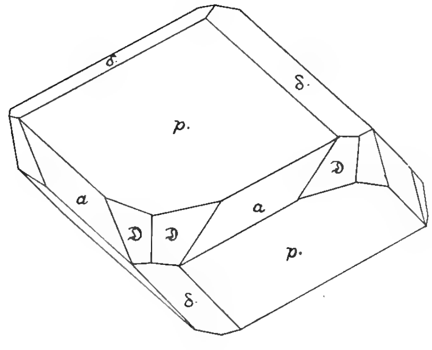
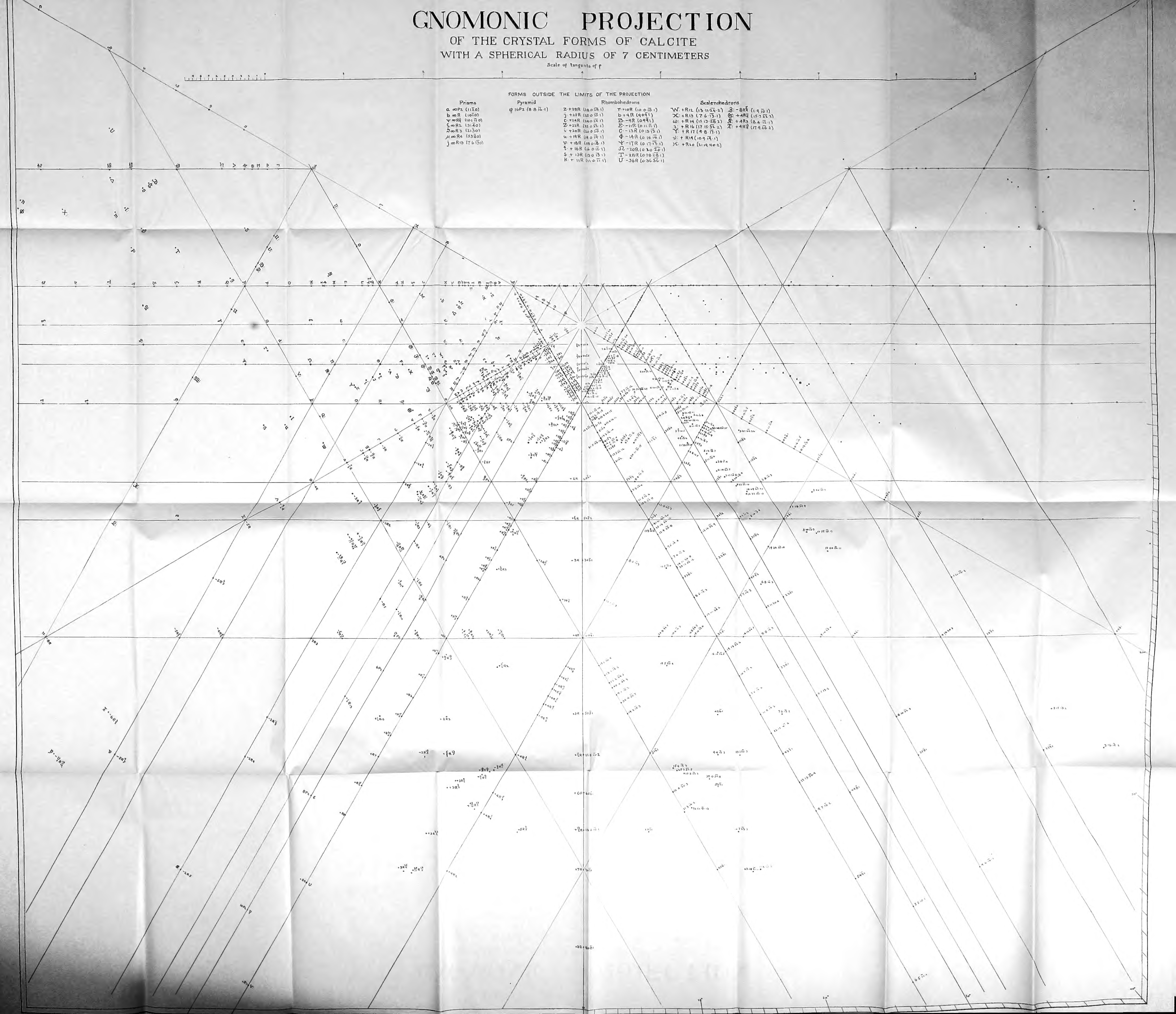


H. P. W. del.

INDEX



GNOMONIC PROJECTION
OF THE CRYSTAL FORMS OF CALCITE
WITH A SPHERICAL RADIUS OF 7 CENTIMETERS
Scale of tangents of ρ
FORMS OUTSIDE THE LIMITS OF THE PROJECTION
Prisms
a ∞P2 (11$\bar{2}$0)
b ∞R (10$\bar{1}$0)
ψ ∞R$\frac{11}{9}$ (10.1.$\overline{11}$.0)
ς ∞R2 (31$\bar{4}$0)
ϑ ∞R3 (21$\bar{3}$0)
μ ∞R4 (53$\bar{8}$0)
j ∞R13 (7.6.$\overline{13}$.0)
Pyramid
φ 16P2 (8.8.$\overline{16}$.1)
Rhombohedrons
z +28R (28.0.$\overline{28}$.1)
j +25R (25.0.$\overline{25}$.1)
c +24R (24.0.$\overline{24}$.1)
Z +22R (22.0.$\overline{22}$.1)
i +20R (20.0.$\overline{20}$.1)
u +19R (19.0.$\overline{19}$.1)
v +18R (18.0.$\overline{18}$.1)
t +16R (16.0.$\overline{16}$.1)
s +13R (13.0.$\overline{13}$.1)
k +11R (11.0.$\overline{11}$.1)
γ +10R (10.0.$\overline{10}$.1)
b +9R (90$\bar{9}$1)
B −9R (09$\bar{9}$1)
Σ −11R (0.11.$\overline{11}$.1)
C −13R (0.13.$\overline{13}$.1)
Φ −14R (0.14.$\overline{14}$.1)
Ψ −17R (0.17.$\overline{17}$.1)
Ω −20R (0.20.$\overline{20}$.1)
T −28R (0.28.$\overline{28}$.1)
U −36R (0.36.$\overline{36}$.1)
Scalenohedrons
W +R12 (13.11.$\overline{24}$.2)
X +R13 (7.6.$\overline{13}$.1)
ω +R14 (15.13.$\overline{28}$.2)
z +R16 (17.15.$\overline{32}$.2)
Y +R17 (9.8.$\overline{17}$.1)
ν +R19 (10.9.$\overline{19}$.1)
ϰ +R20 (21.19.40.2)
B −8R$\frac{5}{4}$ (1.9.$\overline{10}$.1)
S +4R$\frac{11}{4}$ (15.7.$\overline{22}$.2)
R +4R3 (8.4.$\overline{12}$.1)
Z +4R$\frac{13}{4}$ (17.9.$\overline{26}$.2)